LAKESHORE CAPACITY STUDY

LAND USE

MAY 1986

Prepared by:

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Ontario

Ministry of Municipal Affairs
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LAKESHORE CAPACITY STUDY

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LAKESHORE CAPACITY STUDY

Muskoka-Haliburton Area

0 5 10 15 20 25 30 35

Scale in kilometres

COMPONENTS:

- Wildlife
- Trophic Status
- All
- Microbiology
- Fisheries
- Land Use

The regional survey by the Land Use Component of cottages on portions of lakes is not included

Note: Circle sizes for Cartographic purposes only

Cartography by Ministry of Municipal Affairs and Housing, 1981

THE DISTRICT MUNICIPALITY OF MUSKOKA
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THE DISTRICT OF NIPISSING
THE PROVISIONAL COUNTY OF HALIBURTON
THE COUNTY OF HASTINGS
THE COUNTY OF VICTORIA
THE COUNTY OF SIMCOE
THE PROVISIONAL COUNTY OF HALIBURTON
THE COUNTY OF PETERBOROUGH
Lake Vernon
Lake of Bays
Lake Couchiching
Lake St. Peter
Gravenhurst
Bracebridge
Huntsville
Dorset
Minden
Haliburton
Bancroft
Muskoka Bay
Muskoka River
Black River
Gull River
Irondale River
Burnt River

LAKESHORE CAPACITY STUDY

LAND USE COMPONENT

Muskoka-Haliburton Area

0 5 10 15 20 25 30 35

Scale in kilometres

1976 Survey of lakeshore residents

1978 Survey of lakeshore residents conducted on trophic status and fisheries items

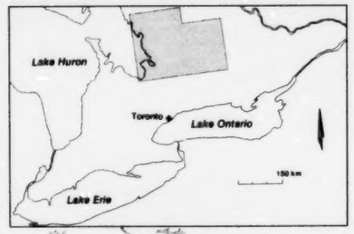
1978 Survey of lakeshore residents LUC lakes

1978

The regional survey of cottages on portions of lakes is not included

NOTE: Symbol sizes for cartographic purposes only

Cartography by Ministry of Municipal Affairs and Housing, 1982



THE DISTRICT OF PARRY SOUND
THE DISTRICT MUNICIPALITY OF MUSKOKA
THE DISTRICT OF NIPISSING
PROVISIONAL COUNTY OF HALIBURTON
THE COUNTY OF VICTORIA
THE COUNTY OF SIMCOE
THE PROVISIONAL COUNTY OF HALIBURTON
THE COUNTY OF PETERBOROUGH
THE DISTRICT OF NIPISSING
THE COUNTY OF HASTINGS
Parry Sound
Bracebridge
Gravenhurst
Huntsville
Orillia
Bancroft
Eagle Lake
Island Lake
Pickerel Lake
Grass Lake
Jacks Lake
Loon Lake
Sand Lake
Three Mile Lake
Groom Lake
Peters Lake
Clam Lake
Doe Lake
Clear Lake
Emsdale Lake
Dotty Lake
Foote Lake
Bella Lake
Oxbow Lake
Perch Lake
Walker Lake
Oudaze Lake
Little Clear Lake
Buck Lake
Troutspawn Lake
Jerry Lake
Solitaire Lake
Harp Lake
Seventeen Mile Lake
Lower Fletcher Lake
McFadden Lake
Bear Lake
Clinto Lake
Lake Vernon
East
Peninsula Lake
Fairy Lake
Took Lake
Kawagama Lake
Johnson Lake
Macdonald Lake
North Lake
Percy Lake
Skeleton Lake
Lake of Bays
Mary Lake
Beattie Lake
Mink Lake
Paint Lake
Chub Lake
Blue Chalk Lake
Plastic Lake
Big Hawk Lake
Kennisis Lake
Redstone Lake
Eagle Lake
Halliburton Lake
Moose Lake
Clearwater Lake
Menominee Lake
Fawn Lake
Big Stephen Lake
Echo Lake
Moot Lake
Wildcat Lake
Rill Lake
Kabakwa Lake
Pine Lake
Glen Lake
Basshaunt Lake
Drag Lake
Ronnie Lake
Sage Lake
Guilfoyle Lake
Maple Lake
Halls Lake
Green Lake
Hurricane Lake
Two Islands Lake
Mistwabi Lake
Eason Lake
Stewart Lake
Leonard Lake
Gilfeach Lake
Healey Lake
Cinder Lake
Brady Lake
Kushog Lake
Boshkung Lake
Twelve Mile Lake
Hazel Lake
Long Lake
McKay Lake
Leech Lake
Wood Lake
Clear Lake
Bigwind Lake
Bird Lake
Mountain Lake
Kashagawigamog Lake
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Billings Lake
Silent Lake
Muskoka Bay
Three Mile Lake
Kahshe Lake
Little Bob Lake
Gull Lake
Sludge Lake
Davis Lake
Head Lake
Four Mile Lake
Dalrymple Lake
Lake Couchiching
Missisagua Lake
Lower Buckhorn Lake
Lovesick Lake
Lake St. Peter
Gull River
Black River
Head River
Burnt River
Severn River
Muskoka River
Magnetawan River
Pondicle River
Stewart Lake
Lake
Muskoka
Lake
Lake
Lake

FOREWORD

Community planners and other professionals involved in the preparation of planning policies for lakeshore development and in the review of specific subdivision proposals have always found it difficult to determine objectively the impact of development on the natural environment. In response to this challenge, the Lakeshore Capacity Study was undertaken to provide a planning tool to assist in evaluating the effects of cottage development on inland lakes and lakeshores. Central to the task was the need to gain a clearer understanding of the relationship between cottage development and its impacts on selected aspects of the natural environment.

To accomplish these objectives, the Ministry of Municipal Affairs carried out the Lakeshore Capacity Study in cooperation with the Ministry of the Environment and the Ministry of Natural Resources.

The Muskoka-Haliburton area of central Ontario was chosen as the Study Area. The homogeneity of the area, which is part of one physiographic region, reduced the need to account for major natural variations among the lakes and watersheds. In addition, the extent of existing development on the lakes varied, permitting an examination of situations ranging from no development to full development.

The Study involved measuring the source of environmental impact, in terms of the lakeshore cottages and their use, and the impact of cottage development in terms of water quality, fisheries, and wildlife habitat. The methods of prediction derived from the research were linked in a simulation model, which is capable of predicting trends in the values of the key indicators of impact.

As the research, analysis and findings of the Study are documented in a set of seven reports, selective reading may be desirable. Those readers who have a general interest in the work are advised to read the Committee Report first, as it provides an overall summary of the findings. This should be followed by the Integration report, in which the simulation model is described. Readers with more specialized interests will find the details of each component of the Study in the other five reports. In each, the reader can select from the table of contents the most important chapters for his or her purposes.

The end product of the Study, the Ontario Lakeshore Capacity Simulation Model, has several features worth noting. The spatial unit addressed by the model is a single lake and the lakeshore. When the model is applied, the number of unknowns related to the natural environment can be substantially reduced, making it easier for planners or other professionals to weigh the environmental effects of development. The model goes a step further to permit predictions of the impact of cottage development when different management policies are selected.

The scope of the simulation model demands some explanation. In its present form, the model applies to cottage development on inland lakes in the Study Area, where the research was conducted. However, the methods of prediction can be adapted to other parts of the province, as long as differences in conditions are taken into account.

The purpose of the Study was to measure the environmental impact of cottages. Commercial and industrial uses were excluded deliberately, in order to simplify the difficult task of measuring cottage impact. The flexibility inherent in the simulation model makes it possible to add other types of land use later, if so desired.

Most of the existing cottage development in the Study Area is located in a single tier along the shoreline. For this reason, the simulation model applies to the immediate lakeshore and not to backshore development. Again, the methods of prediction developed for cottages near the lake can be adapted to measure the impact of cottage development in other forms.

The model was designed to measure the physical and chemical impacts of cottages. Accordingly, it does not address other planning concerns, such as social and economic impacts. While these were recognized as essential considerations in decision-making, the specific objective of Phase III of the Lakeshore Capacity Study was to find practical ways of producing better technical data regarding environmental impact.

Now that Phase III of the Study is completed, with the production of the Ontario Lakeshore Capacity Simulation Model (OLCSM), the next step envisaged is to apply the model experimentally within the Ministry. In this setting, model output can be tested in a variety of actual development situations. When this period of experimental use has been concluded and the results assessed, the three participating ministries will be able to determine whether the model should be adapted to other parts of the province and whether it should be made available more widely.

The Ministry of Municipal Affairs considers the OLCSM to be a potential planning tool but recognizes that the technical and organizational implications of its use must be examined. While this is underway, the model will be available for testing as an additional planning tool to supplement the information normally required to evaluate a planning policy or development proposal. However, the model will not be used in the decision-making process, which will still rest on the customary range of planning considerations.

This Land Use report describes the models developed by the Land Use Component planners and social scientists to predict cottage use.

ACKNOWLEDGEMENTS

The Land Use Component predictive models could not have been developed without the cooperation of cottagers in the Muskoka-Haliburton area who responded to our questionnaires. Municipal and regional government staff in the Study Area also assisted, by supplying information regarding road location, quality and maintenance.

Three senior research analysts with the Land Use Component, Laurier F. Therrien, Nicholas J. O. Miles and William K. Carroll, made major contributions at crucial stages of the work.

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In addition, valuable suggestions emanating from the peer review assisted the author in the final editing of this report.

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At the request of the Lakeshore Capacity Steering Committee, the following specialists reviewed the Land Use Component work program (1977) and this report (1982). Their contributions are acknowledged with thanks.

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PREFACE

This report is intended to provide a general understanding of the two models developed by the Land Use Component research group to predict cottage use. Selected supporting data are included.

Two technical reports provide supplementary material. The Technical Report on Cottage Typology (Miles, 1980) describes the analysis of cottage use patterns. The Technical Report on Land Use Component Models to Predict Cottage Use (Carroll et al., 1982) documents the modelling process in more detail.

The Land Use Component models are included in the Ontario Lakeshore Capacity Simulation Model (OLCSM), which is described in the report on Integration (Teleki and Herskowitz, 1986). Forecasts of cottage use generated by the Land Use Submodel act as the driving variables in the OLCSM, which predicts the impact of cottage development on water quality, fisheries and wildlife.

Step-by-step instructions for applying the Land Use Submodel appear in the OLCSM User's Guide (Teleki and Herskowitz, 1982).

1. INTRODUCTION

The Province of Ontario contains thousands of inland lakes which offer a wide variety of recreational opportunities. The lakes are popular for swimming, boating and fishing during the summer and for downhill skiing, cross-country skiing and snowmobiling during the winter.

For many years, community planners in Ontario have had difficulty evaluating subdivision proposals for cottage development on the shores of inland lakes. The problem stems from the absence of technical knowledge with which to determine objectively whether the cottages are likely to have adverse effects on the lake and surrounding land.

Similar problems are encountered in drafting official plan policies for cottage areas. Even more specific aspects of lakeshore planning, such as zoning standards and site planning, are hampered by the lack of relevant technical data.

Without a recognized method of predicting impact, conflicting claims regarding the ecological repercussions of lakeshore cottages tend to generate confrontation.

While development proponents sometimes minimize the adverse effects, cottage owners often foresee dire consequences. Reconciliation of such extreme positions is unlikely, as long as crucial gaps remain in scientific knowledge of the ecological relationships inherent in lake-watershed systems.

1.1 LAKESHORE CAPACITY STUDY

The objective of the Lakeshore Capacity Study Phase III was to develop a systematic method of predicting the impact of lakeshore cottages on selected aspects of the inland lake environment. It was clear from the initial work in Phases I and II that an in-depth examination of certain specific lake features, such as water quality and fisheries, could be expected to produce practical results.

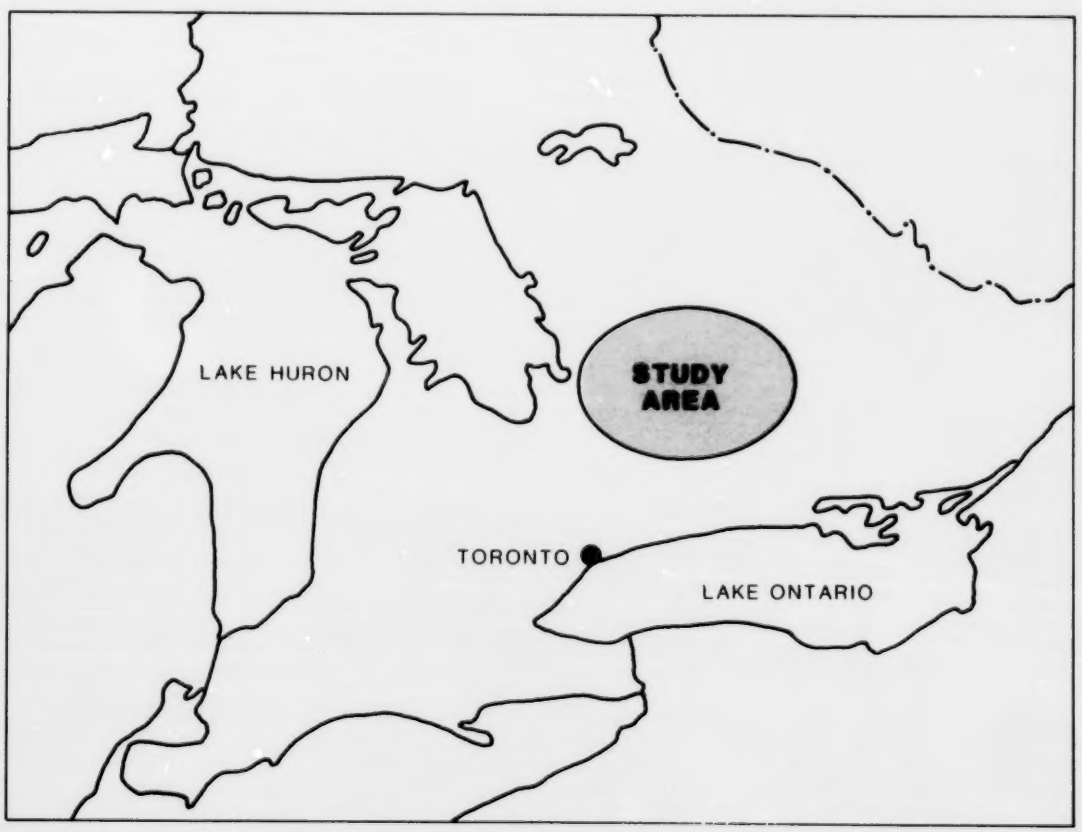


Figure 1. Muskoka-Haliburton Study Area

Further, the land elements of the land-lake system could be taken into account through wildlife-habitat investigations. Related to each of these was the need for more effective ways of quantifying cottages on the lakeshore, to enable identification of consistent relationships between cottages and water quality, fisheries and wildlife.

As current scientific understanding of lake-watershed systems is incomplete, the model to be developed in Phase III was not viewed as the ultimate solution. Rather, a more realistic expectation was that it would be sound enough to merit practical application and flexible enough to allow future refinement.

Finally, it was clear that no model could solve all lakeshore planning problems. Nevertheless, by measuring the probable impacts of cottage development, the model could substantially reduce the number of unknowns with respect to environmental impact, making it easier for a planner to weigh the environmental factors along with other considerations. In this way, the model could assist in lakeshore planning at the provincial, regional and local levels.

1.2 STUDY AREA

The Study Area selected was the Muskoka-Haliburton area of central Ontario. As this area was within one physiographic region on the Precambrian Shield, it had similar soils and plant communities, thus reducing the need to account for major natural variations among the lakes and watersheds.

With respect to cottages, the extent of existing lakeshore development varied, permitting examination of situations ranging from no development to full development. The largest urban complex within a reasonable driving distance was Metropolitan Toronto, with a population exceeding two million (Figure 1).

1.3 ROLE OF THE LAND USE COMPONENT

The Land Use Component was one of several components responsible for the research necessary to develop models capable of predicting the impact of lakeshore development on the environment (Figure 2).

The specific role of the Land Use Component was to investigate the lakeshore cottages, with a view to deriving a more appropriate method of quantifying cottage development than simply counting the number of cottages. The assumption was that cottages varied in the degree of impact they generated, depending on the type of sewage disposal system, size of lot and level of cottage use. This report is focussed on cottage use.

2. OBJECTIVE

The objective of the Land Use Component was to develop a model to predict the level of cottage use for lakeshore cottages on a specific lake, as input to other Lakeshore Capacity Study models.

Two units of measurement were chosen to describe cottage use. One was "cottage-days", where one cottage-day represented one cottage in use for one day. The other was "user-days", where one user-day represented one cottage in use for one day by one person. Thus, the cottage use for a family of four people, at the cottage for three days, would be recorded as three cottage-days or twelve user-days.

Some of the implications of the objective merit elaboration. As the cottage use predictions would be needed prior to approval of a development proposal, it would not be possible to draw on data regarding cottages or cottagers to assist in forecasting. Thus, the timing would place some constraints on the selection of possible predictors.

Another consideration was the need for compatible units of measurement, as the cottage use predictions were intended as input to other Lakeshore Capacity Study models. The Trophic Status model, for example, was being designed to predict the phosphorus concentration in the lake. As the amount of anthropogenic phosphorus contributed to the lake via septic systems was related to the number of people at the cottages during the year, the appropriate cottage use measurement would be user-days (annual). In contrast, the Fisheries net productivity model was being designed to predict fish harvest. This was dependent in part on the angling effort by cottagers which, in turn, was related to the number of anglers from cottages on the lake. As the latter could be derived from the number of days cottages were occupied during the fishing seasons, the appropriate cottage use measurement would be cottage-days (during fishing seasons).

Further, a practical model must be able to produce cottage use projections expeditiously. Accordingly, the variables selected as predictors would have to be restricted to those for which values would be readily available, so input data could be assembled quickly.

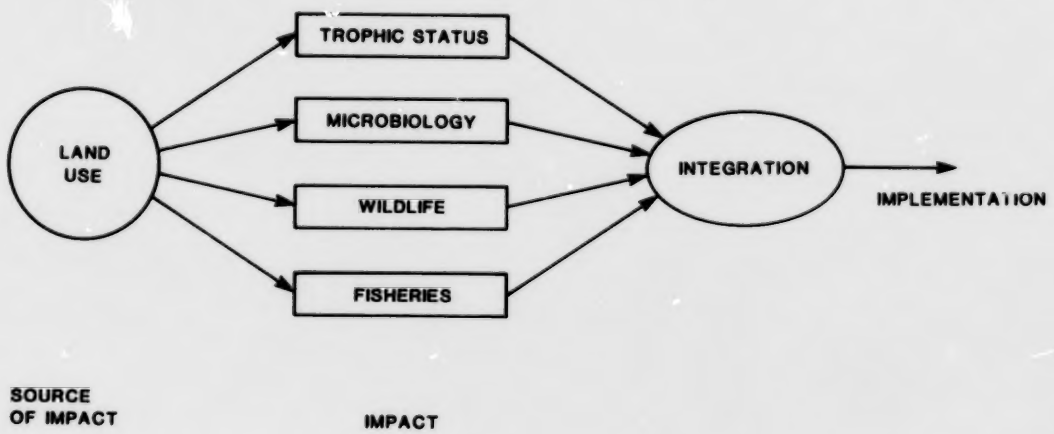


Figure 2. Components of Lakeshore Capacity Study

3. LITERATURE REVIEW

A search of the literature, in 1977, revealed that considerable work had been done on the use of cottages but much of it was descriptive rather than quantitative. Even in the latter category, while many studies produced estimates of annual cottage use, few identified the factors associated with different levels of use. The relevant material noted in this chapter pertains to the level of cottage use, existing models to explain variation in cottage use, and planning policies influencing cottage use.

3.1 LEVELS OF COTTAGE USE

The number of days cottages were occupied during the year was recorded in various studies, as a measure of cottage use. Selected examples are recorded here, for comparison with the findings of the Land Use Component for lakeshore cottages in the Muskoka-Haliburton Study Area.

A report by the American Society of Planning Officials on the impact of second home development in the United States indicated that the median occupancy during the year was 53 cottage-days (ASPO, 1976). The figure varied by region, from a low of 47 in the West to 59 cottage-days per year in the Northeast. Occupancy also varied by season, depending on such factors as seasonal recreational facilities at the second home and the time of year when families traditionally took their vacations.

In Wisconsin, a study of lake property owners showed that the average use of the property was 118 cottage-days per year (Klessig, 1973). When permanent residents, who comprised 18% of the sample, were excluded, the average use was 60 cottage-days.

In Alberta, a survey of cottages on Lac La Biche (Runge and Steffen, 1977) indicated that each cottage generated an average of 0.54 person-years of use, or 197 user-days, during the period from May to October. Winter use was not included, although 28% of the respondents used their cottages in winter. The method of recording cottage use on a simple calendar, with an open square for each day during the survey period, was subsequently adapted for use in the Land Use Component questionnaire.

In Ontario, the Ministry of Natural Resources employed data from the Ontario Recreation Survey to estimate cottage use (Ross and Peck, 1979). By relating the average use of cottages owned by Ontarians in Ontario to the average party size for those using a cottage, it was estimated that cottages were used about 49 to 57 cottage-days during the year.

A study of recreation and community development in the District of Muskoka and the Town of Bala was conducted in 1967, under a Federal/Provincial Rural Development Agreement (Project Planning Associates, 1970). Data from the survey of cottages indicated that the average annual use of a cottage was 80 cottage-days. Families with higher incomes used their cottages more, for an average of 85 cottage-days.

Cottages in Muskoka were surveyed again in 1972, as part of a study of the role of recreation in the economy of the District of Muskoka (JMT Engineering, 1973). The average cottage use during the year was 72 cottage-days.

Based on these studies, the median cottage use in the United States appears to be in a range similar to the average use of cottages in Ontario. The somewhat higher averages in Muskoka may be due to a higher percentage of permanent residents in the sample.

3.2 EXISTING MODELS TO EXPLAIN VARIATION IN COTTAGE USE

In the published literature, two studies were described which attempted to explain variation in the use of existing cottages.

In the early 1970's, the Upper Great Lakes Regional Commission funded a study of lake property owners in northern Wisconsin (Klessig, 1973). The purpose was to learn more about the lake property owners, in order to determine their potential role in lake management. Step regression analysis was used to determine the reasons for variation in the time spent at the lake property. The three factors identified were the number of improvements on the property, the age of the owner and the location (rural or urban) of the owner's permanent residence. Together, they explained 43% of the variance in the annual number of cottage-days at the lake.

In 1970, the College of Agriculture at Pennsylvania State University undertook a study of environmental quality aspects associated with seasonal home communities (Gamble et al., 1975). Most of the communities studied were located on lakes, with a few on the ocean or a bay. One of the objectives was to determine the attitudes of seasonal home occupants regarding environmental quality. Regression techniques were used to explain the reasons for the variation in annual use of the second home. The most significant variable was the seasons of the year the home was used – for each additional season, the use of the home increased by nine cottage-days. Also, older families and families who were willing to accept

restrictions on their activities used their seasonal homes more. Lower use was associated with excessive noise, poor water quality and less emphasis on the quality of the home and community. Together, these variables explained 26% of the variation in seasonal home use.

Some of the factors identified in these two studies as being associated with different levels of cottage use might assist in estimating the use of existing cottages. However, it was not feasible to employ them in attempting to predict cottage use prior to development, because information on cottages and cottagers would not be available at that stage.

3.3 PLANNING POLICIES INFLUENCING COTTAGE USE

When the conceptual approach to a model to predict cottage use was developed, it was recognized that planning policies and zoning regulations could affect access to the cottage and, in turn, cottage use.

Subsequently, problems associated with a change from seasonal to permanent use of cottages in Ontario were documented in a discussion paper on seasonal residential conversions (Ontario Ministry of Housing, 1978). Among the problems were demands that roads be improved and kept open all year. Winter road maintenance and snow clearing for weekend recreational use was considered inadequate for permanent use. It was clear that the standards were lower for roads providing access to seasonal cottages than for those serving permanent residences.

Some municipalities used "Seasonal Residential" zoning to prohibit permanent use of cottages and thereby limit increases in the cost of services. In the Discussion Paper, an alternative concept of "Limited Services" zoning was advocated, as a means of discouraging permanent use. It was argued that it would be easier to enforce than seasonal occupancy restrictions.

4. CONCEPTUAL APPROACH TO THE ACCESSIBILITY MODEL

Several possible methods of predicting cottage use were considered by the Land Use Component group. One simple method was to assume that each cottage might be used all year, so the number of cottages would simply be multiplied by 365 days to estimate the annual cottage-days. While this "worst-case" assumption would undoubtedly be safe, it would drastically overstate cottage use. This was evident when it was compared with the average annual use of cottages recorded in previous studies. For cottages in Muskoka, estimates of actual use ranged from 72 to 85 cottage-days, which was less than one-quarter of the maximum use (365 cottage-days) during the year.

The implications of high predictions were considered. As the water in the lake is adversely affected by cottage use, the simulation model would respond to high cottage use estimates by forecasting lower water quality. In response to such a forecast, stringent limits would be placed on the creation of cottage lots, in order to preserve environmental quality. If this were to occur on many inland lakes, the effect on the total supply of cottage lots could be immense and the possibility of locating a cottage on the lakeshore could become more and more remote. In view of the implications, the "worst-case" approach was rejected.

4.1 AVERAGING MODEL

Another simple method of predicting was to assume that the average number of cottage-days during the year would apply to both existing and proposed cottages. As this method recognized actual levels of cottage use, the predictions would be realistic when averaged for all lakes. The problem with the Averaging Model was its inability to reflect differences in cottage use between lakes.

4.2 ACCESSIBILITY MODEL

In order to develop a model that would be sensitive to lake-to-lake variations in cottage use, the first step was to recognize the constraints imposed by the need to make predictions prior to cottage construction. At that point in time, no information would be available regarding improvements on the lot; number of seasons the cottage was occupied; family size, age or income; or attitudes and perceptions regarding noise or water quality.

The next step was to identify the kinds of information that would be available when a proposed development was submitted for approval. The major items were location of the subdivision, number of lots, and type of access to the lots. Official plan policies and zoning regulations for cottage areas, if any, would also be known. Each of these was examined in the light of its potential value as a predictor of cottage use.

If the time required to reach the cottage was a factor affecting cottage use, then any aspect of cottage accessibility that would tend to increase or decrease the travel time could be relevant. The underlying assumption was that good access was associated with higher cottage use while difficult access was associated with lower cottage use.

Some of the lakes in the Study Area had a considerable number of small islands. As many cottagers consider a cottage on an island in Muskoka the quintessential cottaging experience, some cottages had water access only. These were unlikely to be used extensively in winter, so it was assumed that cottages accessible only by water would tend to have lower cottage use. Thus, the type of access to the cottage was selected as a possible independent variable, to assist in predicting cottage use.

The climate in the Muskoka-Haliburton area also affected cottage access, as snow-clearing was required to keep roads open during the winter. While major roads were cleared, many of the narrow or unimproved roads leading to cottages were closed. Accordingly, another possible explanatory variable was access road open in winter.

Other variables were sought that would reflect either the degree of difficulty or the length of time involved in reaching the cottage. It was evident from field experience in the Study Area that unimproved roads were often muddy in wet weather, making some cottages temporarily inaccessible. Accordingly, the distance travelled on poor roads to reach the cottage was selected as a third possible predictor.

Another aspect of cottage accessibility was the distance from the cottage to urban centres in the region. The rationale was that permanent residents would need banking, medical and other services that were available only in an urban centre. Therefore, those who intended to use their cottage as a permanent residence would be more likely to choose locations reasonably close to one of the larger urban centres in the Study Area. In contrast, those who used their cottages on weekends or long weekends usually brought their supplies from home, so they might tend to choose more remote locations. Based on this reasoning, the distance from the cottage to the nearest

urban centre was added as a fourth possible explanatory variable.

The method of determining appropriate values for these accessibility variables was an intrinsic part of the conceptual approach. The ideal prediction would indicate the level of cottage use each year, for the life of the cottage. While the ideal was not attainable, it was feasible to use official plans, transportation plans and other planning documents as legitimate sources of information for coding the independent variables. This would ensure that future conditions were taken into account in the model, to the degree possible at the time of the prediction.

This approach could make a considerable difference in the predicted annual cottage use. For example, if a proposed subdivision on the lakeshore had water access only at the time of the proposal, and water access was specified in operating the model, the predicted cottage use would be relatively low. But if the official plan included a proposed major road that would provide access all year to the subdivision, and road access all year was specified in the model, the predicted cottage use would be relatively high. Thus, the recognition of planning documents and the incorporation of planned future conditions was a vital part of the Accessibility Model conceptual approach.

The various steps already described, from the application for subdivision approval to the prediction of the annual number of cottage-days per cottage, are set out in the Accessibility Model conceptual diagram (Figure 3). Knowing the number of lots proposed, it would be possible to estimate the maximum number of cottages, as zoning by-laws usually permit only one principal building on a registered lot.

Where the type of access was the same for each lot, the predicted annual cottage-days for the subdivision would be calculated by multiplying the predicted annual cottage-days per cottage by the number of lots (cottages). Where the type of access differed, lots with the same type of access would be grouped, a prediction would be made for each group, and the separate predictions would then be aggregated to provide the prediction for the entire subdivision.

The final step involved conversion of the predicted cottage-days for the subdivision to user-days. This would be accomplished by multiplying the predicted number of cottage-days for the subdivision by the average number of persons per cottage for the entire sample of cottages surveyed. This "global" average would be used for every subdivision.

This conceptual approach was used as a guide in determining the scope of the cottage use data required from cottagers. It was also a reference point for selecting information needs regarding roads, distances, snow clearing, planning policies and zoning regulations.

To sum up, variations in average annual use between cottages on different lakes would be taken into account in the Accessibility Model by using as predictors selected accessibility characteristics associated with cottage use. Similarly, variations in annual cottage use between cottages on the same lake would be taken into account by making separate predictions for groups of cottages with different types of access.

4.3 COTTAGER MODEL

When the conceptual approach to the Accessibility Model was formulated, the possibility of employing cottage use information to assist in predicting was dismissed because it was not considered feasible to obtain such data prior to cottage construction. Later, when new insights into cottage use patterns were provided by the cottage typology analysis, the possibility of exploiting the data for predictive purposes was explored. The result was the conceptual framework for the Cottager Model. It is described in Chapter 8, following the description of the cottage typology in Chapter 7.

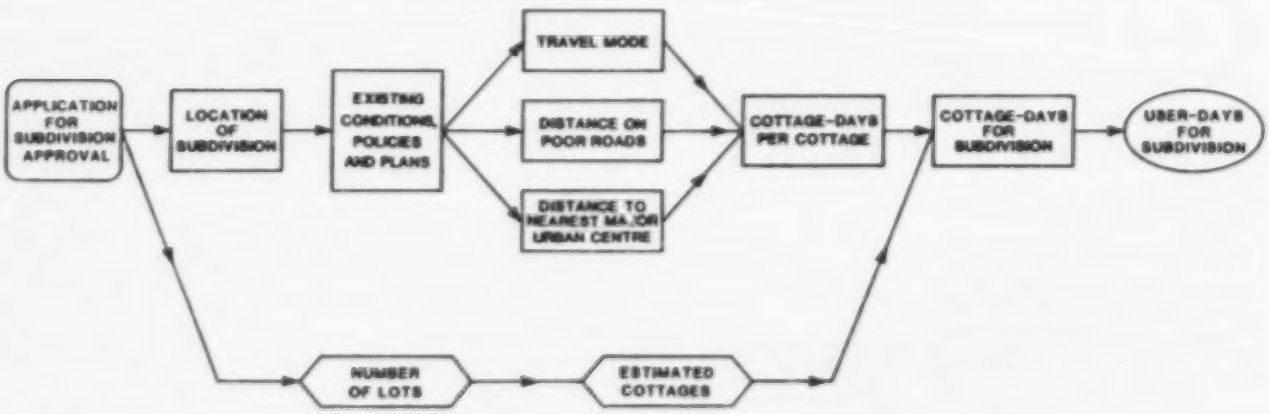


Figure 3. Accessibility Model: a conceptual diagram linking cottage accessibility and cottage use

5. RESEARCH DESIGN

The Land Use Component research to develop a model to predict cottage use was designed to proceed in sequential stages. Each stage depended in part on the preceding work and each contributed to the subsequent work.

The literature search and the conceptual approach have been described in Chapters 3 and 4, respectively. The latter provided a clear focus for selecting the data required for model construction. This included information on cottage use, type of access to the cottage, road standards and distances from the cottages to urban centres in the region. The cottage use data was collected from the cottagers, through a sample survey. Information on roads was obtained from the Ministry of Transportation and Communications, regional and local governments in the Study Area, and field checks. Relevant planning policies and controls were identified through contacts with local, regional and provincial planning departments.

The cottage use information was analyzed before proceeding with the modelling process. Packaged computer programs in the Statistical Package for Social Sciences (SPSS)* were employed to provide data on annual cottage-days, annual user-days, patterns of cottage use throughout the year, and household size, for individual lakes and for the entire sample.

The process of model building was then undertaken. Multiple regression analysis was selected as the best method of developing a linear regression equation. The regression analysis identified the variables with the most influence on the forecast and indicated the weights to be attached to each. The analysis also identified the variables with the least influence on the forecast, which assisted in eliminating unnecessary variables.

The candidate variables measured the various accessibility characteristics described in the conceptual approach to the Accessibility Model. Both continuous and dichotomous variables were employed. The continuous variables, such as distance from the cottage to the nearest urban centre, were expressed as distance measurements. The dichotomous variables were treated as dummy variables.*

To assist in selecting the best set of independent variables, five stepwise regression procedures were employed: forward selection, backward elimination, stepwise, maximum R^2 and minimum R^2.** The conceptual and technical aspects of these procedures are documented in standard statistical text books.

At each step, the values of several standard statistical measures were considered. These are described in the Lakeshore Capacity Study Technical Report **Land Use Component Models to Predict Cottage Use** (Carroll et al., 1982). Specifically, they included the coefficient of multiple determination, mean square error, Student's t test and analysis-of-variance F-ratio.

Packaged computer programs in the Statistical Analysis System (SAS) were employed for modelling.*** This system included, in addition to the standard statistical measures, Mallory's Cp and the predicted error sum of squares.

Mallory's Cp assisted in identifying the equation with the least number of independent variables which could predict nearly as accurately as the equation with all appropriate predictors. The Cp value approximates the number of variables in the regression equation when the mean square error approximates the mean square error for the equation including all appropriate predictors.

The predicted error sum of squares assisted in evaluating the predictive power of each regression equation. If the regression equation could predict the dependent variable (cottage-days) with the same degree of accuracy for another sample of cottages drawn from the same area, the value would be similar to the value of the error sum of squares.

The final step was to evaluate the accuracy of the model predictions. This was accomplished by comparing the predictions of cottage use with actual cottage use, for each lake surveyed. The model predictions were based on imputed data and benchmark data; "actual" cottage use was the information obtained from cottagers through the survey.

To sum up, the Land Use Component research to develop a model to predict cottage use was designed to progress through six related stages, namely, literature search; conceptual approach; data collection; data analysis (cottage use); model construction; and evaluation of the accuracy of model predictions. The organization of this report reflects the research design.

* SPSS User's Guide, 1979 Edition. SPSS Inc., Chicago, Illinois, U.S.A.

* Dummy variables are assigned a value of either 1 or 0, to indicate the presence or absence of a particular condition. In this case, the travel mode variables were treated as dummy variables. Thus, the travel mode variable depicting "road in summer; road in winter" was given a value of 1 if the cottage was accessible by road in summer and in winter; otherwise, it was assigned a value of 0. As the travel modes were mutually exclusive, only one travel mode could have a value of 1.

** Computer symbols are used in this report to denote statistical measures.

*** SAS User's Guide: Statistics, 1979 Edition. SAS Institute, Inc., Cary, North Carolina, U.S.A.

6. DATA COLLECTION

Information regarding cottages and cottagers in the Study Area was collected through two surveys, each of which played a special role in the work of the Land Use Component. The 1978 Survey of Lakeshore Residents concentrated largely on cottage use and the responses provided the data base for developing the predictive models. This major survey and the supplementary survey (Autumn Survey of Lakeshore Residents) which followed it are described in this chapter.

6.1 1978 SURVEY OF LAKESHORE RESIDENTS

The 1978 Survey of Lakeshore Residents was designed to collect data from a representative sample of cottages on inland lakes in the Lakeshore Capacity Study Area, as a basis for model development.

A specific boundary was needed for survey purposes, so the boundaries of the District Municipality of Muskoka and the Provisional County of Haliburton were chosen, with two adjustments. On the west, the Georgian Bay lakeshore was excluded, because the Great Lakes were not considered inland lakes in the context of the Lakeshore Capacity Study. On the east, the townships in Algonquin Park were excluded, because land development in a provincial park did not require approval under the Planning Act.

As the Lakeshore Capacity Study was concerned with the impact of cottages on the environment, it was essential to include cottages used all year as well as those used intermittently. Thus, the term "cottage" was used in a broad sense to include all single-family residential buildings on the lakeshore. As lakeshore development in the Study Area was primarily single-tier development, most cottages had lake frontage. In the few situations where cottages were located in two or three tiers, all were included.

A geographic cluster sampling technique was chosen as the most efficient way of deriving regional estimates. One-ninth of each township (about 2080 hectares) was selected as the most appropriate cluster size and a grid was drawn on that basis. Where the townships were irregular in shape, the uniform grid was extended to provide clusters of similar size. This produced a total of 378 clusters, from which 40 were initially selected on a random basis as sample blocks.

The total number of cottages to be surveyed was determined in relation to the estimated number of cottages in the Study Area. Based on published reports and contacts with regional and county officials, it was estimated that there were about 35,000 cottages in Muskoka and Haliburton. From this figure, it was calculated that a minimum of 3,000 cottages should receive questionnaires in order to ensure a sufficient number of valid responses.

The next step was cottage enumeration. Starting with the sample block selected first, and proceeding in sequence, field staff located and numbered each cottage in each sample block. The required minimum of 3,000 cottages was reached in the 38th sample block selected. The remaining cottages in that sample block were then recorded, to produce a total enumeration of 3,280 cottages.

Questionnaires were distributed to the enumerated cottages in July and on the Civic Holiday long weekend early in August. Later, at the end of August, call-backs were made to all non-respondents, to determine the number of "non-contacts" (cottages where the questionnaire had not been picked up) and to encourage a higher rate of response. As there were relatively few non-contacts (about 1%), it was assumed that they created no significant bias in the responses.

The call-backs were successful in generating a renewed wave of returns. A response rate of 39% was achieved, despite three interruptions in mail service during the period from late July to October.

The questionnaire was designed to collect cottage-use data for a full year, from July 1977 to June 1978. To make completion of the questionnaire as simple as possible, a calendar was provided and the cottage owners were asked to record on the calendar the number of people at the cottage on each day it was in use. From this information, it was possible to calculate both cottage-days and user-days for each cottage and, when aggregated, for each lake.

6.2 AUTUMN SURVEY OF LAKESHORE RESIDENTS

It was apparent from the 1978 Survey of Lakeshore Residents that most of the cottage use during the autumn, winter and spring was associated with either permanent use or long weekends. Therefore, it was assumed that cottagers who used the cottage intermittently could recall their use of the cottage with an acceptable degree of accuracy for these periods of relatively low use. The question remained, however, whether they could recall their cottage use accurately for the previous summer,

when they used the cottage more frequently. Accordingly, the Autumn Survey of Lakeshore Residents was designed to obtain cottage-use data for the most recent four months, from July to October 1978. This information would then be compared with the cottage use recorded for the same months of the previous year.

The questionnaire was mailed in November to each respondent who had provided his/her name and address on the summer survey return, as an indication of willingness to participate in a follow-up survey to up-date some of the information. Over 80% of the respondents had included the information necessary for mailing, which probably reflected their deep interest in their recreational properties. Whatever the reason, the response rate for the Autumn Survey soared to 74% (775 questionnaires).

In the Autumn Survey, cottagers were asked to record their cottage use for the previous four months, so the maximum length of recall was five months. This was substantially less than the recall period in the earlier survey, in which cottagers had been asked to record their cottage use for the previous twelve months. Thus, it was possible that the information recorded might be quite different.

For the cottages covered in the Autumn Survey, the daily cottage-days for July 1 to October 31, 1977, were plotted as a bar graph. Similarly, the daily cottage-days for July 1 to October 31, 1978, were plotted on a transparent overlay. When the position of the overlay was adjusted slightly so the weekends coincided, a remarkable similarity was evident in the pattern and level of cottage use. Further, the correlation coefficient between the cottage-day data for 1978 and 1977 was 0.75. As some variation in use can be expected to occur from year to year, even for the same cottages, the strength of this correlation affirmed the ability of respondents to recall their cottage use for the previous summer. Therefore, the 1978 Survey of Lakeshore Residents was considered to be a valid record of cottage use over the full 12 months, from July 1977 to June 1978.

7. HIGHLIGHTS OF SURVEY FINDINGS

In general terms, the pattern of cottage use in Ontario was well known. It was widely recognized, for example, that summer was the period of greatest use, that winter use was increasing and that many cottages built originally for seasonal use were now being used all year. The 1978 Survey of Lakeshore Residents provided much more specific information for the Study Area.

7.1 COTTAGE USE LEVELS

A record of the intensity of cottage use was obtained from the calendar in the questionnaire. Of particular interest was the information on the number of days per year the cottage was used. It seemed logical to assume that the carrying capacity of the lakeshore would be greater for cottages used intermittently than for those used all year. How much greater would depend in part on the amount of use.

As the level of cottage use varied with the season, the average use for each month was computed. The seasonal pattern was quite striking (Figure 4). It did not break into quarters but rather into a long winter season and a short spring, summer and fall. The low-use winter months were November to April. During this period, average monthly use of the cottage was only five days whereas in the high-use summer months, July and August, the monthly

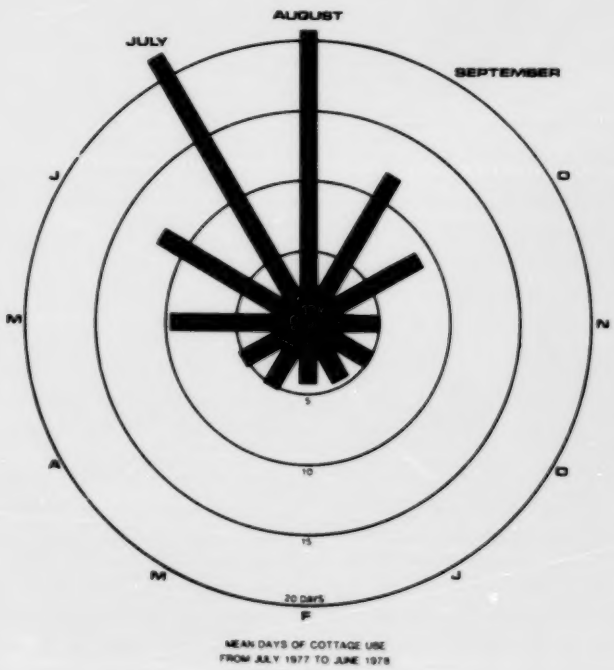


Figure 4. Cottage use, by month

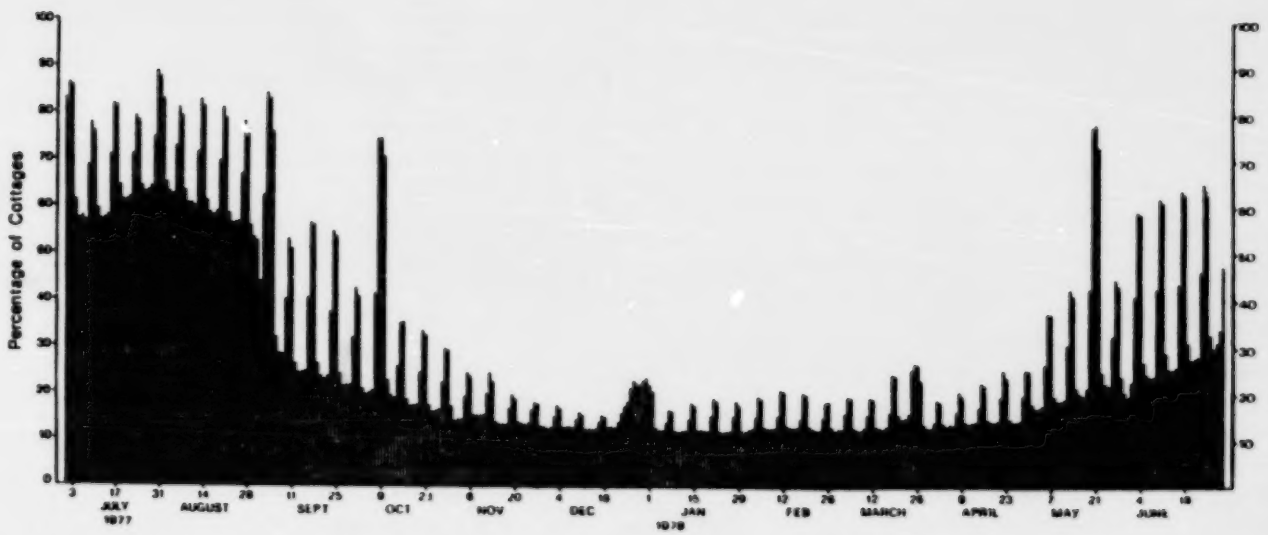
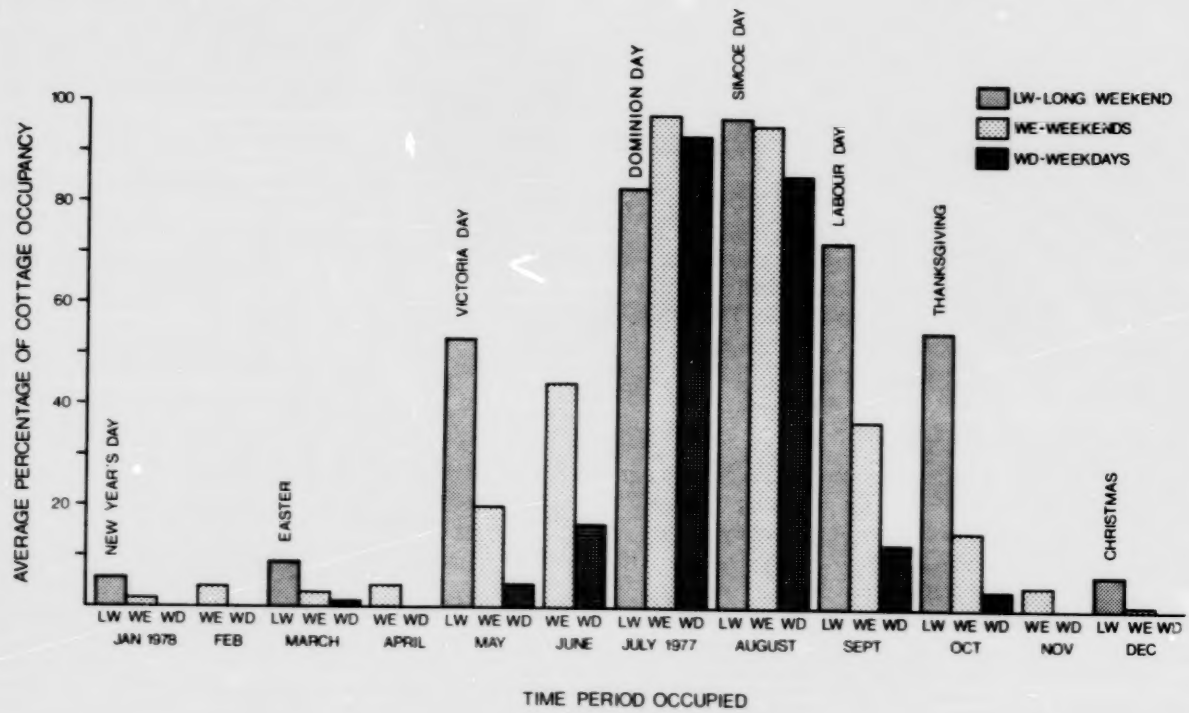


Figure 5. Percentage of cottages occupied in Muskoka-Haliburton, daily for the year ending June 30, 1978

SUMMER (JULY AND AUGUST)



WEEKENDS

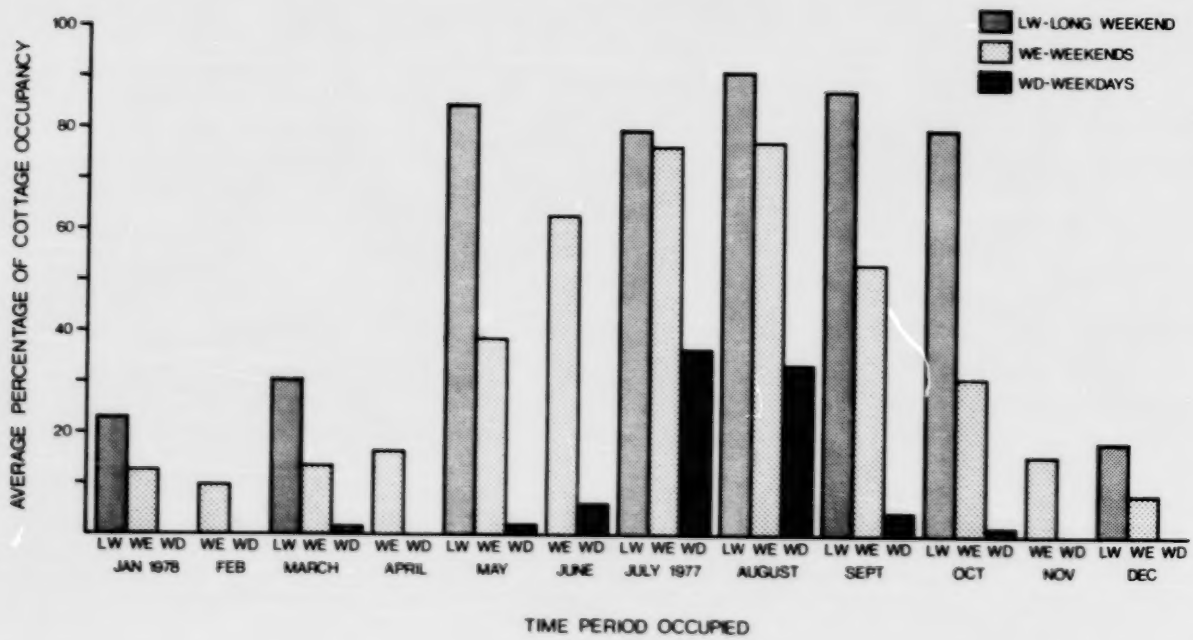
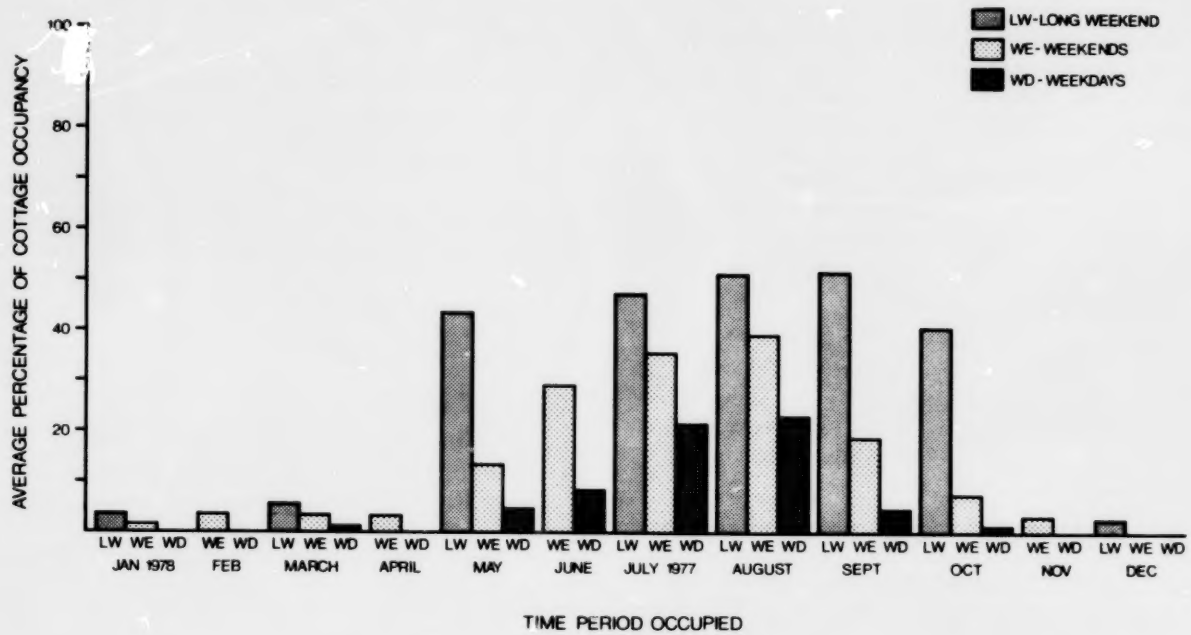


Figure 6. Cottage use patterns, by cottage typology group

LONG WEEKENDS



EXTENDED SUMMER

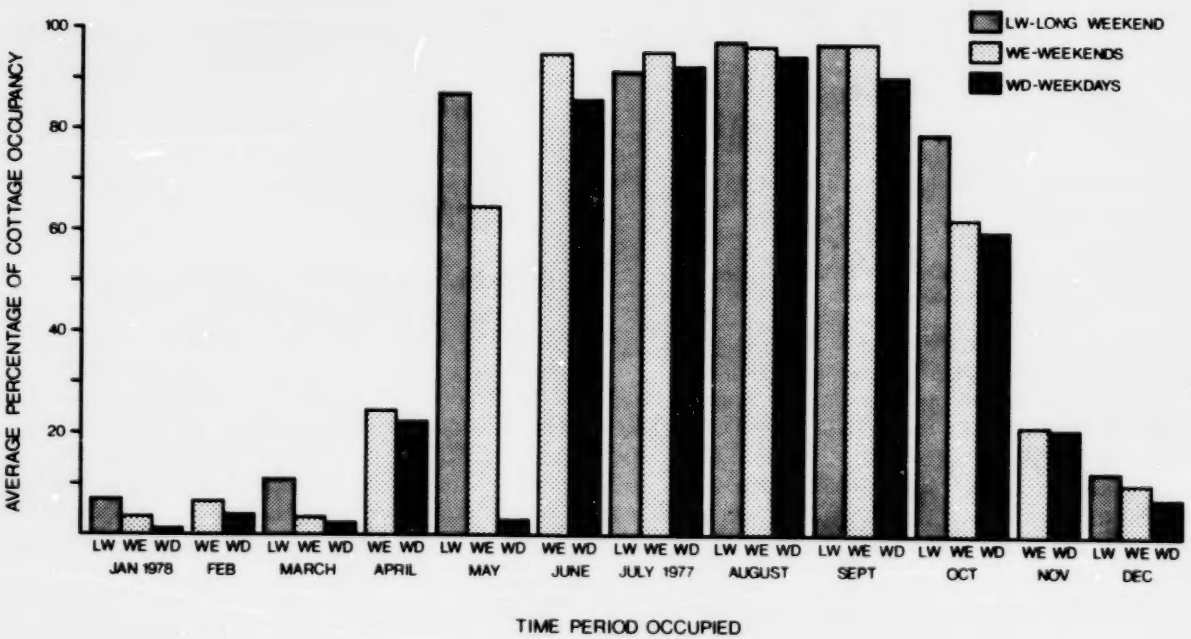


Figure 6. Cottage use patterns, by cottage typology group

average was twenty-two days. Spring and fall were transitional periods, with an average of twelve days in June and September and nine days in May and November. The cottages were in use for an average of 116 days during the year, which was roughly one-third of full-time use.

This seasonal pattern of cottage use was important to several study components. For example, the Fisheries Component research group had indicated that ice-fishing in the winter was hard on the trout fishery. Similarly, the Wildlife Component group had stated that loons were more vulnerable to human disturbance during their nesting period in June. So knowing the timing of the heavy influx of cottagers was relevant to the analysis and prediction of cottage impact on the environment.

The daily use data (Figure 5) confirmed that there was a consistent weekly pattern of cottage use, not only during the summer but also throughout the rest of the year. More cottages were used on weekends than on weekdays. Further, more cottages were used on long weekends and other holidays, such as Dominion Day, than on other weekends.

While this information provided an illuminating overview of cottage occupancy, it did not link the use patterns to individual cottages. To do this, a statistical analysis was undertaken to develop a typology of cottages.

7.2 COTTAGE USE PATTERNS

The purpose of the cottage typology was to classify the cottages according to their predominant use patterns, so the survey findings would provide a more realistic reflection of actual cottage use. It was known at this stage that the level of cottage use varied considerably among cottages, so it was not surprising that the global average of 116 cottage-days for the year seemed unrealistically high to some cottage owners. It was considered unlikely that each cottage was unique, so it was assumed that the cottages could be distinguished by their different patterns of predominant use and grouped accordingly. Cottage owners would then be able to identify a use pattern similar to their own and the average annual use for that particular group of cottages would be more likely to approximate their actual level of use.

In fact, the overall average was relatively high because the survey included cottages occupied all year and cottages occupied for part of the year as a principal residence. The latter group had been identified when the questionnaire for the 1978 Survey of Lakeshore Residents was pre-tested in the Study Area. Usually, the owners spent four to five months at the cottage and the rest of the year in a warmer climate. While these cottages comprised a small proportion of the total sample, they were important because each cottage had relatively high use.

The different types of cottages already observed included those used primarily on long weekends, those used all year, and those used for part of the year as a principal residence. In addition, it was known that some cottages were occupied most of the summer while others were used almost every weekend. It was expected that the statistical analysis would identify some of these types of predominant use and possibly others.

The cottage typology analysis is described in detail in the Land Use Component Technical Report on Cottage Typology (Miles, 1980). Some of the steps are noted briefly here, to assist in understanding the nature of the typology.

Initially, the days in use each month, for each cottage, were assigned to three separate categories: weekdays, weekends and long weekends. For example, when a cottage was occupied for the entire month of September, the thirty days were assigned as follows: four days to September long weekends, ten days to September weekends and sixteen days to September weekdays. For the entire year, this process required 32 variables, including 12 for weekdays, 12 for weekends and 8 for long weekends (as four months had no long weekends.)

Principal component analysis of the 32 variables describing the pattern of use for each cottage identified four distinct groups of cottages, each with similar use patterns. The next step was to compute four component scores for each cottage, to indicate the relationship of the cottage to each of the four groups. Cluster analysis of the component scores then distributed the cottages among five mutually exclusive groups.

Group 1. *Summer (July and August)*
Cottages used intensively during the summer (July and August) but much less at other times.

Group 2. *Weekends*
Cottages used predominantly on weekends in the spring, summer and fall.

Group 3. *Long Weekends*
Cottages with low levels of use, except on long weekends in the spring, summer and fall.

Group 4. *Extended Summer*
Cottages with high levels of use in the spring, summer and fall.

Group 5. *All Year*
Cottages used all year, as a principal residence.

The nature of each group is illustrated in a bar chart (Figure 6). When the charts are compared, the differences in the predominant patterns of use are readily apparent. The Summer (July and August) group had a high percentage of cottages occupied on both weekdays and weekends during July and August. In contrast, while the Extended Summer cottages were also occupied on weekdays and weekends, their use extended beyond the summer into the spring and fall. The Weekends and Long Weekends groups included cottages used in the spring, summer and fall; one group was characterized predominantly by weekend use and the other by long-weekend use. The occupancy rate for the All Year group was the same throughout the year, so a chart was unnecessary.

The cottage typology groups differed in their average cottage use and household size. Table 1 shows the percentage of the total sample of cottages in each

typology group and the cottage use (average number of cottage-days per year) and household size (average number of persons per cottage) for each group.

Nearly one-quarter of the cottages were used predominantly on long weekends from June to September. Their average use for the year was 39 days.

Cottages used predominantly during the summer (July and August) or on weekends during the spring, summer and fall, each comprised 28% of the sample. The Summer cottages were used for an average of 89 days per year and the Weekend cottages for an average of 81 days.

Cottages used all year, as a principal residence, were occupied for an average of 363 days, roughly four times as much as the Summer and Weekend cottages. Thus, the carrying capacity of the lake and lakeshore, in terms of number of cottages, is likely to be considerably greater for cottages used intermittently than for those used all year.

Table 1. Cottage use and household size for five cottage typology groups

COTTAGE TYPOLOGY GROUP	Percent of Total Sample	COTTAGE USE Average Cottage-days per Year	HOUSEHOLD SIZE Average Persons per Cottage
	%	no.	no.
Summer (July and August)	27.7	88.7	3.69
Weekends	28.0	80.5	3.60
Long Weekends	23.9	39.3	3.39
Extended Summer	7.8	175.2	2.64
All Year	12.6	363.1	2.56
All Cottages	100.0 (N = 1139)	116.03	3.07

7.3 SUMMARY OF SURVEY FINDINGS

Several conclusions were drawn from the analysis of cottage use in the Muskoka-Haliburton area:

1. There is a consistent seasonal pattern of cottage use. Based on the monthly average for all cottages, the period of highest use extends for only two months, July and August; the period of lowest use extends for six months, from November to April. Transitional months occur both in the spring (May and June) and in the fall (September and October).

2. There is also a consistent weekly pattern of cottage use throughout the year. More cottages are occupied on weekends than on weekdays. Further, more cottages are occupied on long weekends and other holidays (such as Dominion Day) than on other weekends.

3. Cottages can be classified into five groups which are internally homogeneous and mutually exclusive with respect to their predominant use patterns.

   Group 1. Summer (July and August)
   Group 2. Weekends (spring, summer and fall)
   Group 3. Long Weekends (spring, summer and fall)
   Group 4. Extended Summer (weekends and weekdays)
   Group 5. All Year

4. The cottage groups differ in level of cottage use. The average annual number of cottage-days for each group is:

Group 1. Summer	88.7
Group 2. Weekends	80.5
Group 3. Long Weekends	39.3
Group 4. Extended Summer	175.2
Group 5. All Year	363.1
All Cottages	116.03

   Thus, cottages used all year, as a principal residence, are occupied about four times longer (363 days) than cottages in the Summer (89 days) or Weekends (81 days) groups.

5. The cottage groups differ also in household size. The average number of persons per cottage is:

Group 1. Summer	3.69
Group 2. Weekends	3.60
Group 3. Long Weekends	3.39
Group 4. Extended Summer	2.64
Group 5. All Year	2.56
All Cottages	3.07

   Thus, cottages in the Summer, Weekends and Long Weekends groups have more occupants than the average, while cottages in the Extended Summer and All Year groups have fewer occupants than the average.

6. The differences in cottage-days and persons per cottage are reflected in the average annual user-days for each group.

Group 1. Summer	327.3
Group 2. Weekends	289.8
Group 3. Long Weekends	133.2
Group 4. Extended Summer	462.5
Group 5. All Year	929.5
All Cottages	356.2

   Despite their smaller household size, cottages in the All Year group have by far the largest average number of user-days during the year. The figure for this group (930 user-days) is roughly double that of the Extended Summer group (463 user-days) and more than triple that of the Weekends group (290 user-days).

8. CONCEPTUAL APPROACH TO THE COTTAGER MODEL

The pattern of cottage use recorded for each cottage in the 1978 Survey of Lakeshore Residents represented the end result of all the decisions made by the cottagers regarding the use of their cottage. When viewed in this way, it was evident that the separate groups in the cottage typology provided a valid basis for predicting cottage use, as they reflected not only decisions influenced by the socio-economic characteristics of cottage owners but also decisions in response to changes in external factors, such as fuel costs and property taxes.

The average annual levels of cottage use for the five typology groups extended over a wide range, from 39 cottage-days for cottages in the Long Weekends group to 363 cottage-days for cottages in the All Year group. These differences offered a compelling rationale for employing the cottage groups as predictors.

Such an approach required information on the proportion of cottages in each typology group in the proposed development. As this would not be known at the time of the prediction, a method of estimating the proportions was needed. Accordingly, it was decided to introduce a system of benchmarking, whereby the cottage typology proportions for the "target" lake (where development was proposed) would be derived from a "benchmark" lake.

The logic for employing benchmark lakes was similar to the rationale for "hot-decking" in survey research. The assumption was that cases with similar values for measured variables (e.g., accessibility characteristics) would also have similar values for unmeasured variables (i.e., cottage typology). The feasibility of the benchmarking rested on the capacity of these measured variables to provide a close fit between the ultimate cottage typology on the target lake and the known typology on its benchmark lake.

The justification for employing the benchmarking process was that the cottage typology data could not be applied without it. Benchmarking provided the missing link (i.e., cottage typology proportions) that enabled the new knowledge of cottage use gained from the typology analysis to be applied in a practical method of predicting cottage use.

By definition, the benchmark lakes were those for which the cottage typology was known, that is, those included in the 1978 Survey of Lakeshore Residents. From this pool of possible benchmarks, the most appropriate lake would be selected. The proportion of cottages in each typology group, for the target lake, would then be assumed to be the same as for its benchmark lake.

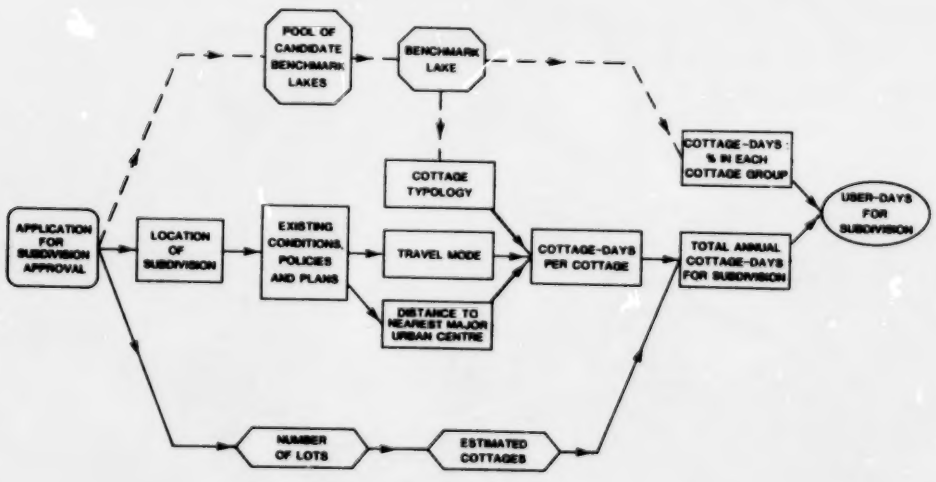


Figure 7. Cottager Model: a conceptual diagram linking cottage typology and cottage use

To assist in selecting an appropriate benchmark lake, the official plan policies and zoning regulations with respect to seasonal versus permanent use of cottages would be examined. For example, if permanent use was not permitted on the target lake, the benchmark lake would have to be one with no cottages in the All Year group. In contrast, if the municipality had no planning policies regarding cottage use, it would be assumed that some cottages would be used all year and this would have to be reflected in the typology of the benchmark lake.

The conceptual framework for the Cottager Model is shown in the network diagram in Figure 7. While the model resembled the Accessibility Model in its overall structure, it differed in employing the cottage typology groups as the major predictors.

The other major difference from the Accessibility Model was the benchmarking process. The proportion of cottages in each typology group, for the target lake, would be derived from its benchmark lake. Subsequently, at the stage when the predicted cottage-days were to be converted to user-days, the proportion of cottage-days in each typology group, for the target lake, would be derived from its benchmark lake. By allocating the total cottage-days for the subdivision to the typology groups, it would be possible to convert to user-days by applying the appropriate household size for each group.

In summary, the Cottager Model would take into account variations in cottage use between lakes, by recognizing differences in accessibility characteristics and planning policies when selecting the benchmark lake. The model would also reflect differences in cottage use between cottages on the same lake, by employing the cottage typology groups as variables. In addition, variations in household size would be taken into account by converting cottage-days to user-days for each typology group.

Overall, the Cottager Model concept incorporated several refinements which were not in the Accessibility Model. While most of these were designed to improve the predictions, the model had to rely on the benchmarking process for estimates of cottage typology. Thus, some of the gains in accuracy would be offset by losses inherent in the benchmarking.

9. ACCESSIBILITY MODEL

The Accessibility Model and the Cottager Model were both designed to predict cottage use. The Accessibility Model derives its predictive power from variations in cottage accessibility, while the Cottager Model exploits cottage use patterns.

The conceptual approach to the Accessibility Model was described in Chapter 4. The development of the model is outlined in this chapter, which includes selected supporting data. More technical detail regarding the modelling process appears in the Technical Report on Land Use Models to Predict Cottage Use (Carroll et al., 1982).

9.1 CANDIDATE VARIABLES

In the conceptual approach to the Accessibility Model, four aspects of cottage access were identified as possible predictors of cottage use. Their selection was based on the literature search and on observation of the Study Area. These four aspects were: type of access to the cottage, access road open in winter, distance travelled on poor roads to reach the cottage, and distance from the cottage to the nearest urban centre. From these general descriptions, nine candidate variables were defined and computed (Table 2).

The type of access to each cottage was expressed in terms of four travel mode variables. Travel Mode 1 was defined as car in summer, car in winter; Travel Mode 2 as car in summer, other in winter; Travel Mode 3 as boat in summer, other in winter; and Travel Mode 4 as no winter use. The percentage of cottages with each travel mode is shown in Table 3.

The travel modes were dichotomous variables so they were treated as dummy variables. For example, for a cottage with water access only, the travel mode variable specifying "boat in summer, other in winter" would be assigned a value of 1 and the other travel modes would each have a value of 0.

The variable "access road open in winter" was also a dichotomous variable, treated as a dummy variable.

To measure the distance travelled on poor roads to reach the cottage, a "poor" road was defined as one that was not hard-surfaced. While this might appear at first glance to be too simplistic, distinguishing between hard-surfaced and other roads reflected indirectly such specific characteristics as the number of travel lanes, radius of curvature and gradient, each of which would affect travel time. As this was a continuous variable, its value was the measured distance (in kilometres) from a hard-surfaced road to the cottage.

Table 2. Candidate variables for the Accessibility Equation

CONTINUOUS VARIABLES	
DISTSUMH	Distance (in km) from the cottage to the nearest high order service centre, in summer.*
DISTSUML	Distance (in km) from the cottage to the nearest low order service centre, in summer.*
INTERACT	Interaction (cross-product) between DISTSUMH and DISTSUML.
MAXPOOR	Distance (in km) from the cottage to the nearest good (hard-surfaced) road, i.e. distance on poor roads.**
DICHOTOMOUS VARIABLES	
TMODE1	Mode of travel to the cottage: car in summer; car in winter.
TMODE2	Car in summer; other in winter (e.g. snowmobile, skiis, foot).
TMODE3	Other in summer (e.g. boat); other in winter.
TMODE4	Car or other in summer; no winter use.
NOPLOW	Access road to the cottage closed in winter.

*Variables DISTWINH and DISTWINL (distance in winter) were removed from the candidate variables, due to their high correlations with DISTSUMH and DISTSUML, respectively.

**Bivariate relationships among the independent variables and between each of the independent variables and the dependent variable (cottage-days) were explored, to determine whether any of the assumptions of regression modelling had been violated. The only adjustment necessary was transformation of the variable 'distance on poor roads' to its reciprocal (MAXPOORX) to produce a more linear relationship with cottage-days. To avoid dividing by zero when the distance on poor roads was zero, 0.003 was added to MAXPOOR. Thus, the new variable MAXPOORX is equivalent to $\frac{1}{\text{MAXPOOR} + 0.003}$

Table 3. Travel mode variables

Computer Mnemonic	Travel Mode	Number of Cottages	Percent of Cottages
TMODE1	Car in Summer Car in Winter	394	34.59
TMODE2	Car in Summer Other in Winter	231	20.28
TMODE3	Boat in Summer Other in Winter	88	7.73
TMODE4	Car or boat in Summer No Winter Use	397	34.85

To measure the distance from the cottage to the nearest urban centre in the region, it was essential to identify both high order and low order urban service centres in the Study Area. The method of selection was based on Christaller's theory of central place, where the central place provides goods and services for people in the surrounding area (Christaller, 1933). The distinction between "high order" and "low order" relates to the number and diversity of goods and services provided, the size of the population and the extent of the tributary area. High order centres could serve a dual role for people in the immediate vicinity, as their wider variety of goods and services includes low order goods and services.

The hierarchy of central places ranges from large metropolitan complexes to small towns and villages. However, in the Study Area the urban centres were all at the lower end of the scale. The largest town was Huntsville, which had a population of 10,480 in 1976. Thus, the high order centres selected were mainly towns and the low order centres were mainly villages.

The initial selection of urban centres was based on population, the number of retail establishments and the diversity of goods and services. This was compared with responses to a question in the survey regarding the urban centres visited most frequently by members of the cottage household. The responses from the cottagers confirmed the initial selection of both high and low order centres.

Table 4. High and low order urban service centres in the Muskoka-Haliburton Study Area

HIGH ORDER URBAN SERVICE CENTRES

Urban Centre	County or District Municipality	Population*	
		1971	1976
Bracebridge	Muskoka	6,903	8,180
Gravenhurst	Muskoka	7,133	7,350
Huntsville	Muskoka	9,784	10,840
Haliburton	Haliburton	899	1,124
Minden	Haliburton	697	590
Bancroft**	Hastings	2,276	2,210

LOW ORDER URBAN SERVICE CENTRES

Urban Centre	County or District Municipality	Population*	
		1971	1976
Bala	Muskoka	462	536
Baysville	Muskoka	283	240
Coldwater	Muskoka	759	803
Dorset	***	n/a	n/a
Mactier	Muskoka	794	690
Port Carling	Muskoka	617	628
Washago	Muskoka	423	442
Wilberforce	Haliburton	229	266

*Source: 1976 Statistics Canada, Population Statistics
**Outside Study Area but serves cottages in the southeast corner of Study Area
***Located on the boundary between Muskoka and Haliburton

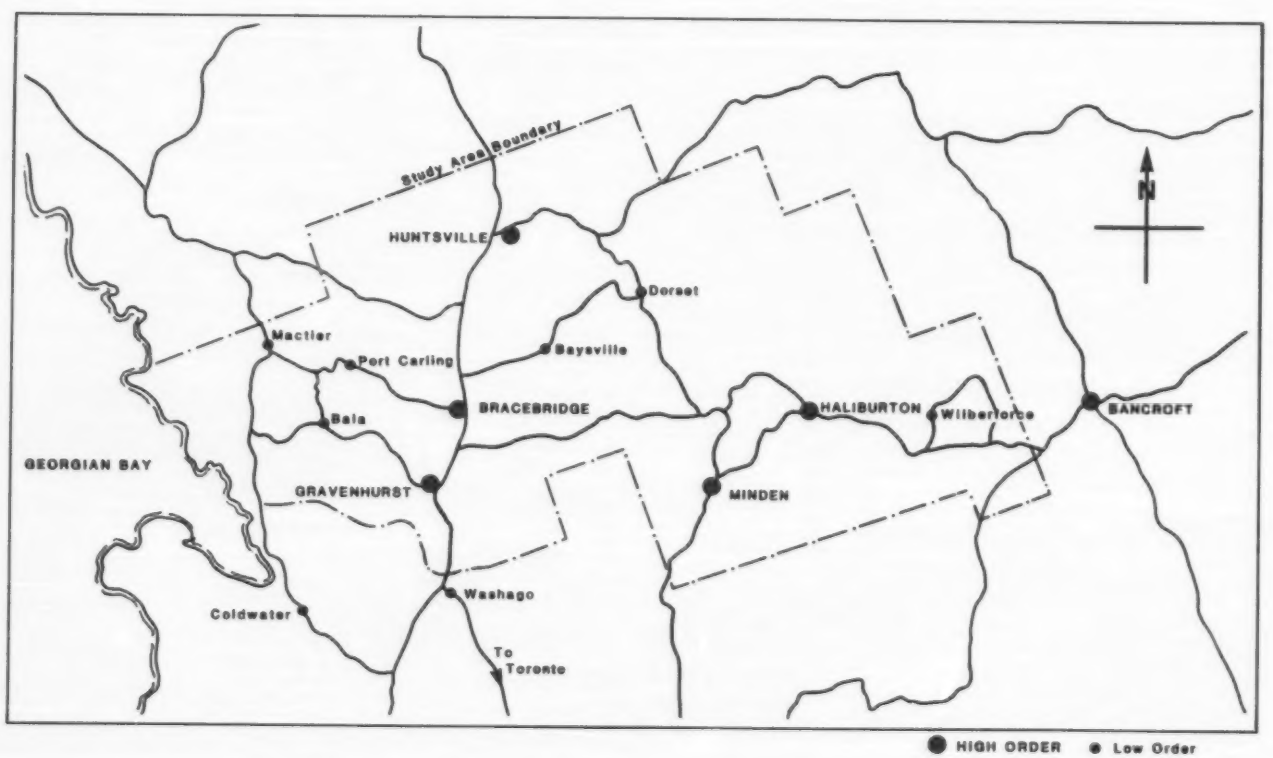


Figure 8. Urban centres in Study Area

They also indicated that cottagers in the southeast corner of the Study Area used Bancroft, which was outside the Study Area, as a high order service centre.

The final selection of urban centres appears in Table 4, together with the most recent population figures at the time the selection was made. These urban centres were used to measure the distance in kilometres from a cottage to its nearest high order urban centre and to its nearest low order urban centre (Figure 8).

The hypothesis that the independent variables were not causally related to the dependent variable (cottage-days) was tested by examining the Pearson product-moment coefficient of correlation between the dependent variable and each of the independent variables. In each case, the null hypothesis was rejected (Table 5). While this did not prove that a true relationship existed between cottage-days and the independent variables selected, it did indicate that such a relationship was possible.

Examination of the correlation matrix indicated that two of the independent variables had a moderately strong relationship with the dependent variable (annual cottage-days). The correlation between cottage-days and the travel mode variable signifying road access in summer and winter, was 0.501; while the correlation between cottage-days and the reciprocal of the distance on poor roads was 0.418. Each of the other independent variables showed a weak but statistically significant correlation with cottage-days.

9.2 REGRESSION EQUATION

The regression equation for the Accessibility Model was developed through multivariate analysis, employing stepwise regression procedures to identify the best equation. No problems were encountered with technique-dependent results, as the five procedures produced the same equations (Table 6).

The proportion of total variance in annual cottage-days explained by the regression equation and measured by the coefficient of multiple determination (R^2) increased with the addition of another variable in each of the first five steps but showed trivial gains in explained variance thereafter. Similarly, the mean square error (MSE) decreased in each step up to the five-variable equation but remained almost constant thereafter. In addition, the C_p closely approximated the number of variables in the equation at the fifth step, thereby identifying that equation as the one with the least number of variables which could predict almost as accurately as the equation using all possible predictors. All of these reasons contributed to the choice of the following equation as the best solution.

Table 6. Accessibility Model regression equations identified by five stepwise procedures*

Number of Variables in Equation	Variable Added in this Step**	Coefficient of Multiple Determination	C_p	Mean Square Error
1***	TMODE1	0.250	150.57	7912.5
2***	MAXPOORX	0.328	19.39	7099.0
3***	DISTSUMH	0.332	14.05	7060.0
4***	TMODE2	0.337	8.19	7017.7
5***	TMODE3	0.340	5.20	6993.1
6	DISTSUML	0.341	5.01	6985.8
7	INTERACT	0.341	7.00	6991.9
8	NOPLOW	0.341	9.00	6998.1

*Forward, Backward, Stepwise, Maximum R^2, Minimum R^2
**Or deleted from next step, as in Backward Elimination procedure.
***All variables statistically significant at or above 0.05 level.

$$R_A = 83.105 + 93.452\,TMODE1 + 0.322\,MAXPOORX - 5.29\,DISTSUMH + 22.655\,TMODE2 + 21.972\,TMODE3$$

where R_A = number of annual cottage-days per cottage predicted by the Accessibility Model regression equation

TMODE1 = 1 when the travel mode is "car in summer, car in winter" (otherwise = 0)

MAXPOORX = the reciprocal of the distance in kilometres from the cottage to the nearest hard-surfaced road

DISTSUMH = the distance in kilometres from the cottage to the nearest high order urban centre

TMODE2 = 1 when the travel mode is "car in summer, other in winter" (otherwise = 0)

TMODE3 = 1 when the travel mode is "boat in summer, other in winter" (otherwise = 0)

The two variables "car in summer, car in winter" and "the reciprocal of the distance from the cottage to the nearest hard-surfaced road" together explained nearly one-third of the variance in annual cottage-days (R^2 = 0.328). This was not surprising in view of the correlation between each of these variables (TMODE1 and MAXPOORX) and cottage-days, and their relative lack of intercorrelation (Table 5).

As expected, the regression coefficient for "distance to the nearest high order urban centre" was negative, confirming that a greater distance would predict a lower level of cottage use when the other variables were held constant (Table 7).

When the Student's t test was applied as each independent variable was entered into the equation, the hypothesis that no relationship existed between the annual number of cottage-days and the independent variable was rejected.

The high value of the F ratio (F = 116.77) revealed that the explained portion of the variance in the annual number of cottage-days was substantially greater than the unexplained portion. Further, the high significance level ($p < .0001$) meant that the regression was unlikely to be a product of chance.

When the values of the predicted error sum of squares

Table 5. Correlation matrix for candidate variables in the Accessibility Equation

	ANNUAL COTTAGE-DAYS	DISTSUMH	DISTSUML	INTERACT	MAXPOOR	MAXPOORX	NOPLOW	TMODE1	TMODE2	TMODE3	TMODE4
ANNUAL COTTAGE-DAYS	1	0.250	−0.194	−0.237	−0.262	0.418	0.213	0.501	−0.139	−0.083*	−0.338
DISTSUMH		1	0.595	0.843	0.663	−0.222	−0.209	−0.299	0.213	0.122	0.057**
DISTSUML			1	0.897	0.378	−0.183	−0.201	−0.329	0.142	0.168	0.113
INTERACT				1	0.553	−0.207	−0.214	−0.348	0.181	0.176	0.096
MAXPOOR					1	−0.553	−0.246	−0.306	0.206	0.122	0.062*
MAXPOORX						1	0.381	0.306	−0.154	−0.089	−0.148
NOPLOW							1	0.249	−0.337	0.224	−0.097
TMODE1								1	−0.365	−0.210	−0.531
TMODE2									1	−0.145	−0.368
TMODE3										1	−0.212
TMODE4											1

N = 1139
Listwise deletion employed
All correlations significant at the 0.001 level or above, except those with an asterisk.
Significance of those denoted * lies between 0.05 and 0.001
Correlations denoted ** are not significant.

(PRESS) and the error sum of squares (SSE) were compared, it was evident that they were similar, indicating that the regression equation could predict the annual number of cottage-days almost as well for a different sample of cottages drawn from the same area.

The final step in evaluating the regression equation was to examine the pattern of residuals in relation to the regression line. As this is described and illustrated in the Technical Report on Land Use Models, it is sufficient to note here that there were no extreme outliers, no marked tendency for the distribution of residuals to depart from normality and no evidence of heteroscedasticity. In short, the assumptions of regression analysis were satisfied.

Together, the five variables in the regression equation explained 34% ($R^2 = 0.340$) of the variance in annual cottage-days among the 1,139 cottages for which responses were received.

Table 7. Regression equation selected for Accessibility Model

Annual Cottage-days = 83.105 + 93.452 TMODE1 + 0.322 MAXPOORX − 0.529 DISTSUMH + 22.655 TMODE2 + 21.972 TMODE3

Variable	Regression Coefficient	Standard Error	Student's t	p
TMODE1	93.452	6.127	15.2	.001
MAXPOORX	0.322	0.029	11.2	.001
DISTSUMH	−0.529	0.166	3.2	.01
TMODE2	22.655	6.907	3.3	.01
TMODE3	21.972	9.837	2.2	.05

Coefficient of Multiple Determination (R^2)	= 0.340
Analysis-of-variance F-ratio (F)	= 116.77 ($p < .0001$)
Error Sum of Squares (SSE)	=7923279
Predicted Error Sum of Squares (PRESS)	=8013450
Mallory's C_p (C_p)	= 5.208
Mean Square Error (MSE)	=6993.1

9.3 PREDICTED COTTAGE-DAYS FOR SUBDIVISION

The regression equation for the Accessibility Model was designed to predict the annual number of cottage-days for one cottage. Where all the cottages in a subdivision have similar accessibility characteristics, the prediction will be the same for each cottage in the subdivision.

As zoning by-laws usually permit only one principal building on a registered lot, it was assumed that each proposed lot represented one potential cottage. Therefore, the number of cottages in a proposed subdivision would be the same as the number of lots.

To apply the regression equation to a given subdivision, the procedure is to multiply the predicted annual number of cottage-days per cottage by the number of lots in the subdivision. For example, if there are 55 lots in the subdivision and if 80 cottage-days per cottage are predicted by the regression equation, the total annual number of cottage-days can be calculated by multiplying 80 x 55 which equals 4,400 cottage-days.

In subdivisions where the type of access differs for some of the lots, the above procedure must be modified to reflect the different levels of cottage use associated with different types of access. If, for example, some lots are on the lakeshore and have road access all year while others are on an island and have water access only, the first step is to separate the lots into two categories according to their type of access. The procedure described above is applied to each category. The totals for the two categories can then be added together, to obtain the predicted cottage-days for the subdivision. In a similar manner, subdivision totals can be summed to yield predictions for the entire lakeshore.

Thus, the same procedure can be followed, whether the prediction is for a portion of a subdivision, an entire subdivision or all subdivisions on a lake, but if there are differences in the accessibility characteristics of lots it will be necessary to disaggregate before predicting and re-aggregate after predicting.

9.4 CONVERSION TO USER-DAYS

The Ontario Lakeshore Capacity Simulation Model employs user-days as one of the predictors of the amount of anthropogenic phosphorus likely to be contributed to the lake from cottages on the lakeshore. It was necessary, therefore, to convert the predicted cottage-days to user-days.

Data from the 1978 Survey of Lakeshore Residents indicated that cottages were used for an average of 116.03 cottage-days and 355.86 user-days annually. When the average number of user-days was divided by the average number of cottage-days, the average number of persons per cottage was found to be 3.07.

To convert cottage-days to user-days, the procedure is to multiply the predicted number of cottage-days by the average number of persons per cottage (3.07). If, for example, 4,400 cottage-days are predicted for the subdivision, the conversion to user-days would be calculated by multiplying 4,400 x 3.07 which equals 13,508 predicted annual user-days for the subdivision.

9.5 THE MODEL

The network diagram depicting the conceptual approach to the Accessibility Model (Figure 3) provided an overview of the model described in this chapter.

The Accessibility Model can also be expressed in the form of an equation:

PREDICTED ANNUAL USER-DAYS FOR SUBDIVISION = $R_A * N * T_x$

where * = multiplication symbol

R_A = number of annual cottage-days per cottage predicted by the Accessibility Model regression equation

N = number of lots in subdivision

T_x = average number of persons per cottage (3.07) for all cottages in the LUC Survey

10. COTTAGER MODEL

The Cottager Model provides a second method of predicting cottage use. Its capability is based largely on patterns of cottage use, expressed as the proportion of cottages in each typology group. As the data base differs from that employed in the Accessibility Model, the two models can be considered complementary.

Initially, the regression equation for the Cottager Model was developed using the five cottage typology groups, that is, Summer, Weekends, Long Weekends, Extended Summer and All Year. The resulting equation explained almost 95% ($R^2 = 0.949$) of the variation in annual cottage use, for cottages in the survey sample for which the typology was known. However, as several calculations were required for each typology group, the model was complicated. For this reason, the possibility of combining some of the groups was explored, as a means of producing a model that would retain its predictive power but be easier to apply.

Cottages in the All Year group had the highest annual use – an average of 363 cottage-days. Thus, it was evident that an error in estimating the proportion of cottages in this group could have a considerable effect on the prediction. In contrast, redistribution of cottages among the groups with low annual use would have relatively little effect on the prediction. Therefore, the Summer (89 cottage-days), Weekends (81 cottage-days) and Long Weekends (39 cottage-days) groups were merged into a new group, which was termed "Seasonal". Cottages in this larger group had an average of 71 cottage-days annually.

A simplified Cottager Model was then developed, based on the three typology groups: Seasonal, Extended Summer and All Year. The regression equation explained 92% ($R^2 = 0.920$) of the variation in cottage use among cottages in the survey sample. While this represented a reduction in explanatory capability, the difference was considered negligible when compared to the larger losses inherent in the benchmarking process. Accordingly, the simplified version was chosen as the more practical Cottager Model.

10.1 CANDIDATE VARIABLES

In the conceptual approach to the Cottager Model (Chapter 8), the groups of cottages identified in the cottage typology (Chapter 7) were selected as possible predictors of cottage use. Underlying this choice was the assumption that the pattern of cottage use reflected the many decisions made by cottagers regarding the use of their cottages. Further, it was assumed that the decisions of other cottagers on the same lake, both now and in the future, would result in similar patterns of use.

The three cottage typology independent variables (Seasonal, Extended Summer and All Year) are defined in Table 8.

Examination of Table 9 indicates the wide variation among the groups in average annual cottage-days, the dependent variable in the Land Use models. The All Year group averaged 363 cottage-days, or about five times more than the Seasonal group (71 cottage-days). Between these two extremes, the Extended Summer group recorded an average of 175 cottage-days, equivalent to about half the year. These differences in annual use gave the cottage typology groups their potential as predictors.

The line graphs in Figure 9 record the percentage of annual user-days in each month, for each typology group. As expected, three distinct patterns emerged. Cottages in the Seasonal group had their peak use in July and August, with over 50% of their annual user-days concentrated in these two months. In contrast, cottages in the Extended Summer group were used over a longer period, with about 40% of their annual user-days in July and August, about 30% in June and September and about 20% in May and October. Cottage use for the All Year group was spread more evenly over the twelve months.

Table 8. Candidate variables for the Cottager Equation

Variable	Variable Description	Computer Mnemonic
COTTAGE TYPOLOGY VARIABLES		
Seasonal	Cottages used intensively during the summer (July and August); predominantly on weekends in the spring, summer and fall; and predominantly on long weekends in the spring, summer and fall.	SEASONAL
Extended Summer	Cottages with high levels of use throughout the spring, summer and fall.	ESUMMER
All Year	Cottages used all year, as a principal residence.	PERM
ACCESSIBILITY VARIABLES		
All variables listed in Table 2		

Table 10. Correlation matrix for candidate variables in the Cottager Equation

	ANNUAL COTTAGE-DAYS	DISTSUMH	DISTSUML	INTERACT	MAXPOOR	MAXPOORX	NOPLOW	TMODE1	TMODE2	TMODE3	TMODE4	SEASONAL	ESUMMER	PERM
ANNUAL COTTAGE-DAYS	1	0.250	−0.194	−0.237	−0.262	0.418	0.213	0.501	−0.139	−0.083*	−0.338	−0.866	0.167	0.915
DISTSUMH		1	0.595	0.843	0.663	−0.222	−0.209	−0.299	0.213	0.122	0.057**	0.196	−0.029**	−0.214
DISTSUML			1	0.897	0.378	−0.183	−0.201	−0.329	0.142	0.168	0.113	0.132	0.027**	−0.182
INTERACT				1	0.553	−0.207	−0.214	−0.348	0.181	0.176	0.096	0.173	−0.004**	−0.206
MAXPOOR					1	−0.553	−0.246	−0.306	0.206	0.122	0.062*	0.216	−0.052**	−0.221
MAXPOORX						1	0.381	0.306	−0.154	−0.089	−0.148	−0.350	−0.027**	0.446
NOPLOW							1	0.249	−0.337	0.224	−0.097	−0.179	−0.017**	0.232
TMODE1								1	−0.365	−0.210	−0.531	−0.374	−0.005**	0.457
TMODE2									1	−0.145	−0.368	0.130	0.008**	−0.165
TMODE3										1	−0.212	0.041**	0.051*	−0.091
TMODE4											1	0.243	−0.021**	−0.278
SEASONAL												1	−0.574	−0.758
ESUMMER													1	−0.111
PERM														1

N = 1139
Listwise deletion employed
All correlations significant at the 0.001 level or above, except those with an asterisk.
Significance of those denoted * lies between 0.05 and 0.001
Correlations denoted ** are not significant.

Also included as candidate variables for the Cottager Model were the nine accessibility variables defined in Table 2. This was done in order to explore the predictive capability of a composite model.

The three cottage typology variables were treated as dummy variables. The number of cottages in each typology group was expressed as a proportion of all the cottages in a proposed subdivision. Thus, the total value for all typology groups was 1. For example, if 20 cottages out of a total of 80 were in the All Year group, the value for that group would be 0.25. But if there were no permanent residents, the All Year group would be assigned a value of 0.

The correlation coefficients between the dependent variable (average annual cottage-days) and each independent variable in the Cottager Model appear in Table 10. As the accessibility variables were considered in Chapter 9, only those correlations involving the three cottage typology variables need to be examined here. A significant negative correlation (-0.866) was evident between cottage-days and the Seasonal group, which comprised cottages with relatively low annual use. In contrast, the cottage typology variables identifying cottages occupied either extensively throughout the spring, summer and fall (Extended Summer) or by permanent residents (All Year) manifested positive correlations with cottage-days (0.167 and 0.915, respectively). These results pointed up, in the language of correlation analysis, the substantial differences in average annual cottage-days among the cottage groups.

The reason for the strong relationship (0.915) between the variable identifying the All Year group and annual cottage-days was the bimodal character of the distribution of cottage-days (Figure 10). The two modes – one at 65 cottage-days and the other at 365 cottage-days – were associated with the Seasonal and All Year groups, respectively. The large difference between these central tendencies was captured in distinguishing the All Year cottages as a group. Clearly, the cottage typology groups, particularly All Year, were powerful predictors of cottage-days.

Another correlation of interest was that between the All Year typology variable and the accessibility variable indicating year-round car access to the cottage. The coefficient of 0.457 revealed a tendency for permanent residents to occupy cottages with accessibility characteristics favorable to year-round use. It was relationships of this kind between objective accessibility features and patterns of cottage use that made it feasible in principle to estimate the cottage typology proportions by employing a benchmarking process.

Table 9. Cottage use and household size for three cottage typology groups

COTTAGE TYPOLOGY GROUP	Percent of Total Sample	COTTAGE USE Average Cottage-days per Year	HOUSEHOLD SIZE Average Persons per Cottage
	%	no.	no.
Seasonal	79.5	71.0	3.57
Extended Summer	7.8	175.2	2.64
All Year	12.6	363.1	2.56
All Cottages	100.0 (N = 1139)	116.03	3.07

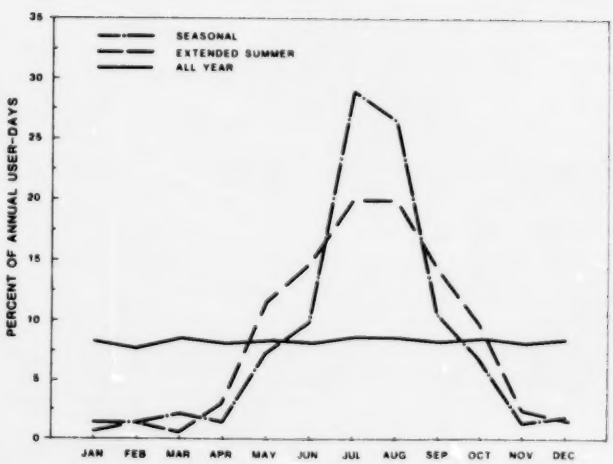


Figure 9. Patterns of cottage use, by cottage typology group

10.2 REGRESSION EQUATION

The regression equation for the Cottager Model was developed through multivariate analysis, by employing stepwise regression procedures to identify the best equation.

All the procedures produced the same solution from Steps 1 to 4, inclusive (Table 11). In Steps 5 and 6, all the procedures except Backward Elimination identified the same variables as explanatory predictors.

The coefficient of multiple determination increased with the addition of each variable to Step 5 ($R^2 = 0.920$) but gained little thereafter. The C_p approximated the number of variables in the six-variable equation more closely than the number in the five-variable one, indicating that the former could predict almost as well as an equation using all possible predictors (Table 12). The mean square error improved only slightly in Step 6.

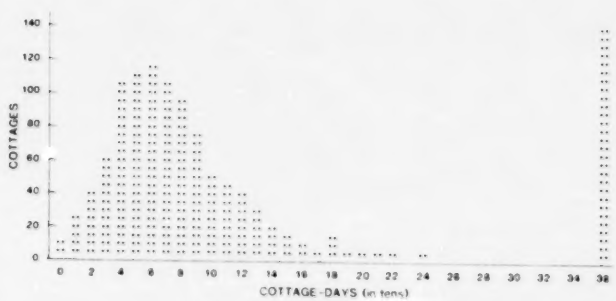


Figure 10. Frequency distribution of cottage-days

Table 11. Cottager Model regression equations identified by five stepwise procedures

Number of Variables in Equation	MIN R^2 and MAX R^2		STEPWISE		FORWARD		BACKWARD	
	R^2	Variable Added	R^2	Variable Added	R^2	Variable Added	R^2	Variable Dropped
1	0.838	PERM	0.838	PERM	0.838	PERM	0.838	PERM
2	0.911	ESUMMER	0.911	ESUMMER	0.911	ESUMMER	0.911	ESUMMER
3	0.918	TMODE1	0.918	TMODE1	0.918	TMODE1	0.918	TMODE1
4	0.919	TMODE2	0.919	TMODE2	0.919	TMODE2	0.919	TMODE2
5	0.920	DISTSUMH*	0.920	DISTSUMH*	0.920	DISTSUMH*	0.920	INTERACT
6	0.920	TMODE3	0.921	TMODE3	0.921	TMODE3	0.920	DISTSUML
7	0.921	DISTSUML	0.921	DISTSUML	0.921	DISTSUML	0.921	TMODE3
		INTERACT/						
		DISTSUMH						
8	0.921	MAXPOORX	0.921	INTERACT	0.921	INTERACT	0.921	MAXPOORX
9	0.921	DISTSUMH	0.921	DISTSUMH			0.921	DISTSUMH

*Five variables in equation.
/ Variable dropped.
R^2 = Coefficient of Multiple Determination

Table 12. C_p and MSE for regression equations, Cottager Model

Steps	MIN R^2 and MAX R^2		STEPWISE		FORWARD		BACKWARD	
	C_p	MSE	C_p	MSE	C_p	MSE	C_p	MSE
1	1173.39	1708.96	1173.39	1708.96	1173.39	1708.96	1173.39	1708.96
2	129.71	935.64	129.71	935.64	129.71	935.64	129.71	935.64
3	44.57	871.84	44.57	871.84	44.57	871.84	44.57	871.84
4	20.67	853.38	20.67	853.38	20.67	853.38	20.67	853.38
5	11.41	845.77	11.41	845.77	11.41	845.77	15.50	848.81
6	8.67	842.99	8.67	842.99	8.67	842.99	9.38	843.52
7	6.42	840.58	10.01	843.25	10.01	843.25	6.41	840.58
8	8.01	841.01	8.42	841.32	8.42	841.32	8.01	841.01
9	10.00	841.75	6.42	840.58			10.00	841.75

MSE = Mean Square Error
C_p = Mallory's C_p

In view of the similarity at Steps 5 and 6 in the coefficient of multiple determination and the mean square error, the following five-variable equation was selected.

$$R_C = 68.312 + 278.578\,\text{PERM} + 102.042\,\text{ESUMMER} + 21.291\,\text{TMODE1} + 12.623\,\text{TMODE2} - 0.191\,\text{DISTSUMH}$$

where R_C = annual cottage-days per cottage predicted by the Cottager Model regression equation

PERM = proportion of cottages in the All Year cottage typology group on the benchmark lake

ESUMMER = proportion of cottages in the Extended Summer cottage typology group on the benchmark lake

TMODE1 = 1 when the travel mode is "car in summer, car in winter" (otherwise = 0)

TMODE2 = 1 when the travel mode is "car in summer, other in winter" (otherwise = 0)

DISTSUMH = the distance in kilometres from the cottage to the nearest high order urban centre

The All Year variable, which was entered first in the regression procedure, explained nearly 84% (R^2 = 0.838) of the variation in annual cottage-days. When Extended Summer was entered next, it explained a further 7% of the variation in cottage-days. Although all of the regression coefficients in the equation were highly significant, the variables representing cottage typology groups were the most reliable predictors.

The estimated regression function showed a remarkably good fit between the equation and the data (Table 13). The coefficient of multiple determination indicated that annual cottage-days per cottage were predictable with a

high degree of accuracy ($R^2 = 0.920$) from the linear combination of cottage typology and travel mode characteristics represented in the equation. Moreover, the close correspondence between the error sum of squares (SSE = 958261) and the prediction error sum of squares (PRESS = 969312) provided assurance that the equation should predict annual cottage-days nearly as accurately if applied to an alternative sample of cottages from the same region.

The ratio of the explained portion of the variation in annual cottage-days to the unexplained portion was extremely high ($F = 2612.55$). In addition, the high significance level ($p < .0001$) indicated that the regression was unlikely to be a product of chance.

The Student's t test was applied as each independent variable was entered into the equation. In each case, the hypothesis that no relationship existed between the dependent variable (annual cottage-days) and the independent variable was rejected.

Together, the five variables in the Cottager Equation explained 92% ($R^2 = 0.920$) of the variation in annual cottage-days among cottages in the survey sample. This was much higher than the 34% of variance ($R^2 = 0.340$) explained by the Accessibility Equation. However, when predicting for a specific lake, the benchmarking process dilutes the strength of the Cottager Equation. It is, therefore, more appropriate to compare the performance of the two models under conditions which simulate practical situations. The results of such tests are presented in Chapter 11.

The method of determining values for the travel mode variables and the distance to the nearest high order urban centre was the same for the Accessibility and Cottager Equations. The values for the cottage typology groups were derived from a benchmark lake, as described in the following subsection.

Table 13. Regression equation selected for Cottager Model

Annual Cottage-days = 68.312 + 278.578 PERM + 102.042 ESUMMER + 21.291 TMODE1 + 12.623 TMODE2 − 0.191 DISTSUMH

Variable	Regression Coefficient	Standard Error	Student's t	p
PERM	278.578	2.952	94.38	.0001
ESUMMER	102.042	3.234	31.51	.0001
TMODE1	21.291	2.199	9.68	.0008
TMODE2	12.623	2.322	5.44	.0001
DISTSUMH	−0.191	0.057	− 3.35	.0001

Coefficient of Multiple Determination (R^2) =	0.920
Analysis-of-variance F-ratio (F) =	2612.55
Error Sum of Squares (SSE) =	958261
Predicted Error Sum of Squares (PRESS) =	969312
Mallory's C_p (C_p) =	11.41
Mean Square Error (MSE) =	845.8

10.3 BENCHMARKING PROCEDURE

The benchmarking procedure was a crucial part of the Cottager Model, as the estimates of cottage typology proportions for the target lake (where development was proposed) were derived from a benchmark lake.

The logic and justification for benchmarking were discussed in the conceptual approach to the Cottager Model (Chapter 8). Criteria for selecting the most appropriate lake from the pool of candidates are outlined in this chapter.

Pool of Candidate Benchmark Lakes

The benchmark lakes were, by definition, lakes for which the cottage typology was known. Thus, the only lakes or portions of lakes which qualified were those included in the 1978 Survey of Lakeshore Residents. It was also essential that each benchmark lake have a sufficient number of cottages to allow each typology group to be represented. Accordingly, the pool of candidate benchmark lakes was limited to the 36 lakes with nine or more cottages.

The cottage and cottage-day proportions in each typology group, for each of the 36 benchmark lakes, are recorded in Table 14. The 1978 Survey of Lakeshore Residents provided a good cross-section of different cottage typology proportions in the Muskoka-Haliburton area. For example, while the cottage typology for the entire sample was 79.5% Seasonal, 7.8% Extended Summer, and 12.6% All Year, on Galla Lake all the cottages were in the Seasonal group. In contrast, on Utterson Lake only 40% were in the Seasonal Group while 55% were in the All Year group.

The pool of candidate benchmark lakes need not be limited to 36 lakes in the future. If cottagers are surveyed on other lakes and the responses are analyzed to obtain cottage typology proportions, these other surveyed lakes can be added as benchmark candidates.

Criteria for Selecting a Benchmark Lake

To select the most appropriate benchmark lake for a specific target lake, the goal was to find the optimum match in terms of cottage typology. As the single strongest predictor in the Cottager Model was the proportion of cottages in the All Year group, the best available indicators of the presence or absence of cottages in this group were employed. There were two possible approaches – one direct and the other indirect.

Direct Approach

The direct approach involved drawing on planning policies and zoning regulations as a source of information regarding permanent versus seasonal use of cottages in the future. Where a zoning by-law prohibited permanent use on the target lake, for example, this situation could be simulated on the benchmark lake by selecting a lake with no cottages in the All Year group.

Alternatively, where the proposed plan of subdivision was in a Limited Services area, it could be assumed that the

Table 14. Cottage and cottage-day proportions in each typology group, for 36 benchmark lakes grouped into seven clusters

Lake Name	COTTAGE PROPORTIONS			COTTAGE-DAY PROPORTIONS		
	Seasonal*	Extended Summer	All Year	Seasonal	Extended Summer	All Year
Cluster 1:						
Oudaze	.9231	.0000	.0769	.6500	.0000	.3500
Waseosa	.6666	.2222	.1110	.2780	.3635	.3586
Walker	.5999	.0667	.3333	.2874	.0748	.6378
Utterson	.4000	.0500	.5500	.1310	.0281	.8409
Muskoka 3	.7600	.1040	.1360	.4785	.1388	.3827
Muskoka 4 (TM1)	.7816	.1149	.1035	.4975	.1626	.3401
Muskoka 5 (TM2)	.9375	.0625	.0000	.8974	.1026	.0000
Muskoka 6 (TM3)	.8500	.1000	.0500	.6327	.1787	.1885
Cluster 2:						
Peninsula	.6666	.0000	.3333	.3130	.0000	.6870
Green	.3810	.0000	.6190	.1033	.0000	.8967
Pine	.3214	.0357	.6429	.0845	.0286	.8868
Kahshe	.9000	.1000	.0000	.7740	.2260	.0000
Canning	.9483	.0517	.0000	.9031	.0969	.0000
Kashagawigamog 1	.4763	.0476	.4762	.1465	.0502	.8034
Kashagawigamog 2	.6123	.1224	.2653	.2729	.1515	.5756
Gull	.9130	.0435	.0435	.7540	.0664	.1796
Cluster 3:						
Gaunt Bay	.6666	.1111	.2222	.3683	.1265	.5021
Muskoka 1 (TM1)	.7966	.1180	.0847	.5406	.1935	.2659
Muskoka 2 (TM2)	.8750	.1250	.0000	.8024	.1976	.0000
Lake of Bays	.7600	.0400	.2000	.4102	.0619	.5279
Dickie	.9032	.0323	.0645	.6992	.0751	.2257
Allen	.9444	.0000	.0556	.7792	.0000	.2208
Cluster 4:						
Galla	.9999	.0000	.0000	1.0000	.0000	.0000
Kawagama	1.0000	.0000	.0000	1.0000	.0000	.0000
Straggle	.9524	.0476	.0000	.8875	.1125	.0000
Kennaway	.9375	.0625	.0000	.8133	.1867	.0000
George's	.9000	.1000	.0000	.6988	.3012	.0000
Little Straggle	1.0000	.0000	.0000	1.0000	.0000	.0000
Cluster 5:						
East	1.0000	.0000	.0000	.9998	.0000	.0000
Cluster 6:						
Six Mile 1 (TM2)	.9143	.0857	.0000	.8467	.1532	.0000
Six Mile 2 (TM3)	.8981	.0926	.0093	.7440	.2100	.0460
Cluster 7:						
Little Kennisis	.8125	.1875	.0000	.6251	.3749	.0000
Haliburton	.6808	.1064	.2128	.3414	.1409	.5177
Riley 1 (TM1)	.8379	.0811	.0811	.5419	.1551	.3029
Riley 2 (TM2)	.7500	.1667	.0833	.4503	.2811	.2686
Riley 3 (TM3)	.9000	.1000	.0000	.7427	.2573	.0000

*Seasonal cottage proportion is not used in the Cottager Model equation. It is included in this table as the sum of the three cottage proportions is 1.

possibility of the road being closed in winter would deter permanent residents. Once again, this situation could be simulated by selecting a benchmark lake with no cottages in the All Year group.

Indirect Approach

An indirect approach was required when neither planning policies nor zoning by-laws were in effect or where permanent use was permitted. This approach relied on the type of access as an indicator of the annual level of cottage use. In other words, it drew on knowledge gained from the Accessibility Model.

Cottages in the All Year typology group had the highest annual level of cottage use – an average of 363 cottage-days. Their presence in this group was associated with certain accessibility characteristics. For example, the cottages tended to have access by car both in summer and in winter; to be served by a hard-surfaced road; and to be located near a high order urban service centre. Thus, indirectly, through similarities in accessibility features

Table 15. Accessibility characteristics of 36 benchmark lakes, grouped into seven clusters

Lake Name	Modal Travel Mode				Mean MAXPOOR**	Mean DISTSUMH***
	TM1	TM2	TM3	TM4*		
Cluster 1:						
Oudaze	0	1	0	0	5.3	22.4
Waseosa	1	0	0	0	7.1	15.5
Walker	1	0	0	0	1.0	16.2
Utterson	1	0	0	0	0.5	19.0
Muskoka 3	1	0	0	0	1.0	20.7
Muskoka 4 (TM1)	1	0	0	0	0.9	13.5
Muskoka 5 (TM2)	0	1	0	0	0.9	14.2
Muskoka 6 (TM3)	0	0	1	0	1.2	13.4
Cluster 2:						
Peninsula	1	0	0	0	0.4	12.0
Green	1	0	0	0	0.6	13.6
Pine	1	0	0	0	0.6	12.9
Kahshe	0	0	1	0	1.6	12.6
Canning	1	0	0	0	1.5	10.0
Kashagawigamog 1	1	0	0	0	4.2	12.5
Kashagawigamog 2	1	0	0	0	0.4	11.6
Gull	1	0	0	0	0.8	6.8
Cluster 3:						
Gaunt Bay	1	0	0	0	1.0	31.5
Muskoka 1 (TM1)	1	0	0	0	2.4	28.9
Muskoka 2 (TM2)	0	1	0	0	3.1	28.8
Lake of Bays	1	0	0	0	0.3	25.6
Dickie	1	0	0	0	1.2	28.0
Allen	0	1	0	0	13.3	41.0
Cluster 4:						
Galla	0	1	0	0	2.6	58.2
Kawagama	0	1	0	0	6.2	49.2
Straggle	0	1	0	0	5.4	56.1
Kennaway	0	1	0	0	2.9	53.5
George's	0	1	0	0	5.4	56.0
Little Straggle	0	1	0	0	5.8	56.4
Cluster 5:						
East	1	0	0	0	15.5	60.6
Cluster 6:						
Six Mile 1 (TM2)	0	1	0	0	4.4	47.2
Six Mile 2 (TM3)	0	0	1	0	4.5	44.7
Cluster 7:						
Little Kennisis	0	1	0	0	6.5	37.1
Haliburton	1	0	0	0	2.2	33.3
Riley 1 (TM1)	1	0	0	0	1.1	41.9
Riley 2 (TM2)	0	1	0	0	2.6	42.5
Riley 3 (TM3)	0	0	1	0	1.0	42.2

*TM1 = Travel Mode 1 (car in summer, car in winter)
TM2 = Travel Mode 2 (car in summer, other in winter)
TM3 = Travel Mode 3 (boat in summer, other in winter)
TM4 = Travel Mode 4 (car or boat in summer, no winter use)
**MAXPOOR = distance on poor roads to reach the cottage
***DISTSUMH = distance from the cottage to the nearest high order urban centre

such as these, it was possible to match the target lake with a benchmark lake that had a similar proportion of cottages in the All Year group (Table 15).

In selecting a benchmark lake, several objective criteria can be applied but there is still an element of subjective judgment inherent in the process. This judgment will normally be exercised by knowledgeable planners and others who have a degree of expert opinion regarding the relevant characteristics of the lakes in question. Thus, the need for skilled judgment in the selection of a benchmark lake can be considered a strength rather than a weakness of the benchmarking system.

When benchmarking is introduced, the theoretical power of the Cottager Model is weakened. Nevertheless, it is evident from the tests of performance described in Chapter 11 that the model retains sufficient capability to qualify as a practical predictive tool.

10.4 PREDICTED COTTAGE-DAYS FOR SUBDIVISION

The regression equation is applied to predict annual cottage-days per cottage. As the prediction is based on the patterns of cottage use identified in the cottage typology, it can be applied to the entire subdivision.

The assumption regarding the number of cottages in the proposed subdivision is the same as for the Accessibility Model, that is, each lot represents one potential future cottage.

To apply the regression equation to a given subdivision, the procedure is to multiply the predicted annual number of cottage-days per cottage by the number of lots in the subdivision. For example, if there are 90 lots in the subdivision and if 200 cottage-days per cottage are predicted by the regression equation, the total annual number of cottage-days can be calculated by multiplying 90 x 200 which equals 18,000 cottage-days.

10.5 CONVERSION TO USER-DAYS

The method of converting predicted cottage-days to user-days is more complicated for the Cottager Model than for the Accessibility Model, as it takes into account differences among the cottage groups in both average annual cottage use and average household size. These differences were evident in Table 9.

In applying the regression equation to predict cottage-days, a benchmark lake was selected to provide the proportion of cottages in each of the three cottage groups. The same benchmark lake is used in the conversion process to provide the proportion of cottage-days attributable to each cottage group (Figure 7).

The effects of differences in the annual level of cottage use from one typology group to another are illustrated in Figure 11, which shows the distribution of cottages and cottage-days, by typology group. For the All Year group, for example, it is evident that the percentage of cottage-days is much higher than the percentage of cottages, due to relatively high annual use per cottage. Conversely, although the Summer, Weekends and Long Weekends groups together comprise 80.1% of all cottages, they generate only 48.6% (Seasonal group) of cottage-days.

The method of converting cottage-days to user-days, for the subdivision, involves the following steps:

Step A. Allot the total cottage-days predicted by the Cottager Model equation for a proposed subdivision to each of the three cottage groups, using cottage-day proportions from the benchmark lake as the basis for allotment.

Step B. Multiply the cottage-days for each cottage group by the average household size for that group, to obtain total user-days for each group.

Average Household Size	
Seasonal	3.57 persons per cottage
Extended Summer	2.64 persons per cottage
All Year	2.56 persons per cottage

Step C. Total the user-days for the three groups, to produce predicted user-days for the entire subdivision.

An example of this method of converting cottage-days to user-days is provided in Table 16.

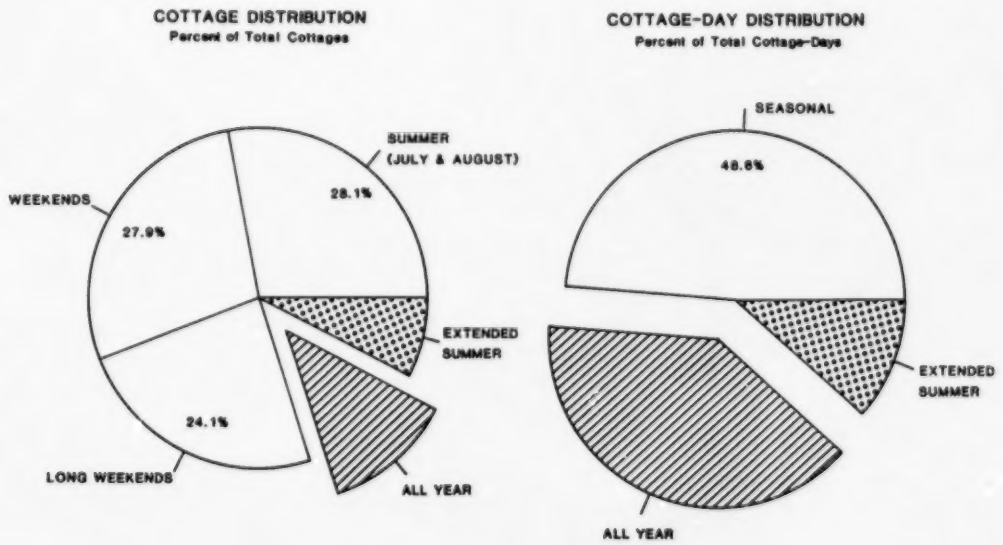


Figure 11. Cottage and cottage-day distribution among cottage typology groups

Table 16. An example of the method of converting cottage-days to user-days

A	B	C	D	E	F	G
Predicted Cottage-days for Subdivision	Cottage Typology Group	Proportion of Cottage-days	Number of Cottage-days	Number of Persons per Cottage	Number of User-days	Predicted User-days for Subdivision
.18,000	SEASONAL	0.60	10,800	3.57	38,556	57,132
	EXTENDED SUMMER	0.10	1,800	2.64	4,752	
	ALL YEAR	0.30	5,400	2.56	13,824	

NOTES
Column A. Assumed. In practice, this would be predicted by applying the regression equations.
Column C. Assumed. In practice, these proportions would be derived from the benchmark lake.
Column D. Calculated by multiplying the predicted cottage-days (A) by the proportion of cottage-days (C) in each typology group (B).
Column E. Average number of persons per cottage, computed from data obtained from cottagers through the 1978 Survey of Lakeshore Residents (Table 9).
Column F. Calculated for each typology group by multiplying the number of cottage-days (D) by the number of persons per cottage (E).
Column G. Calculated by aggregating the number of user-days for each typology group (F).

10.6 THE MODEL

The network diagram depicting the conceptual approach to the Cottager Model (Figure 7) provided an overview of the key aspects of the model which have been described in this chapter.

The Cottager Model can also be expressed in the form of an equation:

PREDICTED ANNUAL USER-DAYS FOR SUBDIVISION = $(R_C * N) * [(S_c * S_x) + (E_c * E_x) + (A_c * A_x)]$

where R_C = annual cottage-days per cottage predicted by Cottager Model regression equation

N = number of lots in subdivision

S_c = proportion of cottage-days in Seasonal group of cottages on benchmark lake

S_x = average number of persons per cottage (3.57) for Seasonal group of cottages

E_c = proportion of cottage-days in Extended Summer group of cottages on benchmark lake

E_x = average number of persons per cottage (2.64) for Extended Summer group of cottages

A_c = proportion of cottage-days in All Year group of cottages on benchmark lake

A_x = average number of persons per cottage (2.56) for All Year group of cottages

11. ACCURACY OF MODEL PREDICTIONS

The regression equations for the Accessibility Model and the Cottager Model were evaluated in Chapters 9 and 10, respectively, in terms of their ability to explain the variation in cottage use among the 1139 cottages in the survey sample. It was important also to establish their accuracy at the level of discrete lakes, since the models were designed to predict cottage use for a proposed subdivision on a specific lake. Accordingly, their predictions were tested on each of the 36 benchmark lakes.

The benchmark lakes were employed for test purposes because survey data were available recording cottage use. This survey information represented "actual" cottage use.

The first step in testing prediction accuracy was to compare the actual and predicted values in terms of a percentage difference, i.e. the difference between the two figures was calculated as a percentage of the actual value. These percentages indicated how closely the model predictions resembled the cottage use levels actually observed. A low percentage difference signified a high degree of accuracy; a positive difference indicated over-prediction; a negative difference indicated under-prediction.

The second step was to establish categories representing the cumulative percentage difference between predicted and actual cottage use. These categories were "within 10% of actual", within 20%, within 30%, and so on. Each of the 36 lakes was then assigned to the appropriate category. Finally, the percentage of the lakes in each category was calculated.

The third step was to compare, for each category, the predictions from the Accessibility Model and the Cottager Model with those from the Averaging Model. The latter prediction of user-days was calculated by multiplying the number of cottages on the lake by the average number of cottage-days (116.03) annually, by the average household size (3.07 persons per cottage).

If the Accessibility Model and Cottager Model were to have practical value in capturing variations in the level of cottage use, their predictions would need to be more accurate than those produced by the Averaging Model.

11.1 ACCESSIBILITY MODEL

When the Accessibility Model was applied to predict cottage use, the predominant accessibility characteristics for all cottages on the lake were substituted for exact data. This was done to simulate the level of detail that would be possible when the model was used in practice.

For the travel mode variables, the imputed values were derived from the most typical travel mode reported by survey respondents for cottages on each lake. For example, if 80% of the cottages on a specific lake were accessible by car all year, the "imputed" travel mode for all cottages on the lake would be car all year. For the continuous variables, distance to the nearest high order urban centre and distance on poor roads, the imputed values were the mean distances for all cottages on the lake.

Expressed in units of annual user-days, predictions from the Accessibility Model were within 20% of actual user-days for 60% of the lakes, while predictions based on the Averaging Model reached this level of accuracy for only 35% of the lakes (Figure 12). Similarly, nearly 70% of the Accessibility Model predictions were within 30% of actual user-days, while the Averaging Model predictions achieved this level of accuracy for less than 50% of the lakes.

These comparisons indicated that the Accessibility Model, by taking into account differences in cottage access, provided more accurate predictions of cottage use than the Averaging Model.

One of the reasons why the Accessibility Model predicted as well as it did was that permanent residents were identified indirectly through the travel mode. This is evident in Figure 13, which indicates that almost all cottages used all year are accessible by car in summer and winter.

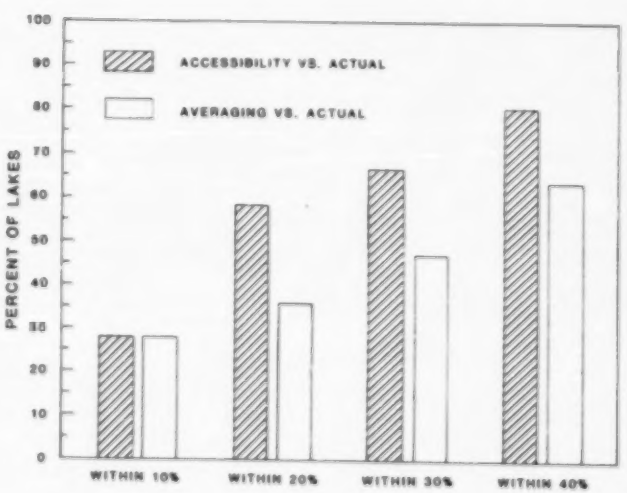


Figure 12. Accessibility Model (imputed data): predicted user-days compared with actual user-days

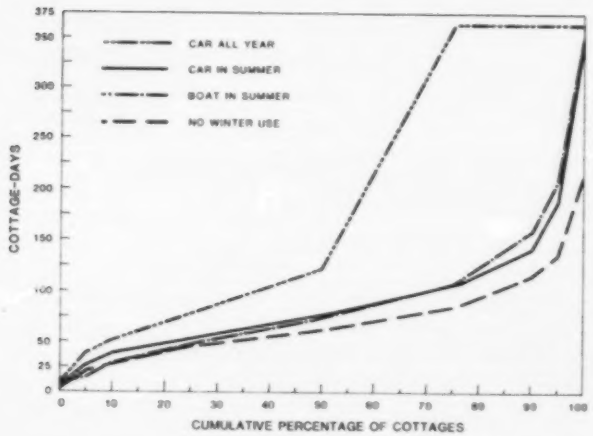


Figure 13. Frequency distribution of travel modes and cottage-days

11.2 COTTAGER MODEL

When the Cottager Model is applied to predict cottage use, the cottage typology proportions are normally derived from a benchmark lake. However, a situation could occur where a new subdivision is proposed on one of the benchmark lakes. In such a case, it would be more appropriate to use the known cottage typology for existing cottages on the same lake, rather than a different benchmark lake.

A somewhat similar situation occurred when the Cottager Model was tested, because the testing was done on the 36 benchmark lakes. In this case, however, a valid test demanded that the performance of the model be evaluated on the basis of the way it would normally be applied. Therefore, for test purposes, the cottage and cottage-day typology proportions had to be derived from a different benchmark lake.

The Cottager Model predictions were within 10% of actual cottage use for about 30% of the lakes; within 20% for about 65% of the lakes; and within 30% for 75% of the lakes (Figure 14). These distributions provided a fairly detailed evaluation of the level of accuracy attained by the model under conditions similar to those in practice.

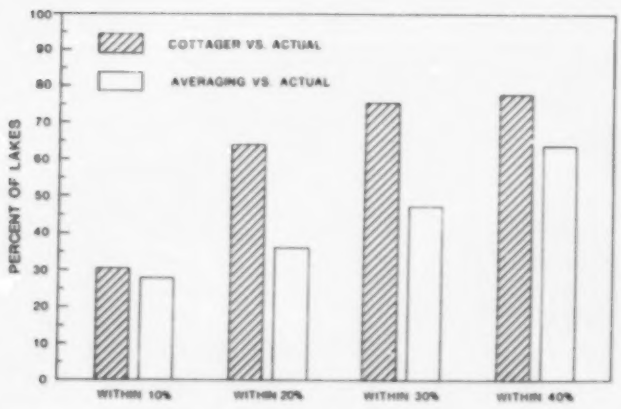


Figure 14. Cottager Model (benchmark data): predicted user-days compared with actual user-days

The Cottager Model predicted within 20% and within 30% of actual cottage use for a substantially higher percentage of lakes than the Averaging Model. For example, the Cottager Model predictions were within 20% of actual for over 60% of the lakes, while the Averaging Model achieved this level for less than 40% of the lakes.

These comparisons demonstrated that the Cottager Model, by taking into account differences in the pattern of cottage use, provided predictions that were generally more accurate than those produced by the Averaging Model.

11.3 EVALUATION AND CONCLUSIONS

The tests of prediction accuracy at the level of discrete lakes provided a basis for evaluating the performance of each model, with a view to deciding whether to retain one or both.

The Accessibility Model predicted better than the Averaging Model, even when imputed data were employed to simulate the degree of precision possible in practice.

The model was objective, simple and efficient – all desirable features. It was objective in the sense that all variables could be measured; relatively simple to apply because it employed only five predictor variables; and efficient in achieving good results with a minimum of effort.

A major advantage of the Accessibility Model was that its predictions could reflect future conditions to some extent. This was possible because Official Plans and Transportation Plans would be used as sources of information for coding the variables. Thus, proposed new roads, road improvements and realignments would be taken into account to the degree to which they could be predicted when the model was applied. Such improvements in accessibility would be reflected in the predictions of cottage use. Therefore, they would tend to be more realistic than predictions based solely on the existing transportation network.

The Cottager Model predicted user-days better than the Averaging Model, even when benchmark data and imputed data were employed to simulate application of the model in practice.

The Cottager Model was more complicated than the Accessibility Model but the logic of the method was clear and valid at each step. Moreover, as the model was programmed in the computer, the calculations did not prove onerous for the user. Thus, the Cottager Model offered a feasible method of predicting.

The benchmarking procedure in the Cottager Model involved an element of subjective judgement. However, this would normally be exercised by knowledgeable planners, or others with some familiarity with local conditions, so it could be considered a strength rather

than a weakness of the benchmarking. In any event, the model proved to be capable of generating predictions that were sufficiently accurate to make it a practical predictive tool.

The test results offered no statistical support for choosing one model over the other. The predictive power of the Cottager Model in practice appeared to be in a range similar to that of the Accessibility Model. Therefore, both models should be retained.

When the Accessibility Model and the Cottager Model are incorporated into the Ontario Lakeshore Capacity Simulation Model (OLCSM), one prediction of cottage use must be selected as input to the Water Quality Submodel and the Fisheries Submodel. Accordingly, a method of choosing the appropriate prediction is outlined in Chapter 12.

The Cottager Model has some potential for improvement. The greatest opportunity lies in the use of planning policies relating to seasonal versus permanent use of cottages in the benchmarking procedure. Where a local government has a policy prohibiting permanent use in designated areas and where it has a zoning by-law indicating where the policy applies, the cottage typology for any proposed subdivision affected by the prohibition can be assumed to exclude permanent residents. Such information can be applied directly in selecting a benchmark lake, by choosing a lake with no cottages in the All Year group. The effect of such a choice on the predicted number of annual user-days would be substantial, because cottages in the All Year group log the highest number of cottage-days (363 annually).

In testing the model predictions in the Study Area, it was not possible to incorporate planning policies regarding seasonal versus permanent use because the lakes used for test purposes were not subject to planning policies of this nature. For this reason, planning policies are not reflected in the evaluation of model performance.

Policies relating to seasonal versus permanent use are in force in some other parts of Ontario, so improvement in the predictive capability of the Cottager Model might be possible if the Lakeshore Capacity Study models were adapted to other areas. Similarly, if local governments in the Muskoka-Haliburton Study Area were to introduce such policies, the Cottager Model might be capable of producing better predictions there.

12. PRACTICAL APPLICATION OF THE LAND USE COMPONENT MODELS

The specific purpose of the Land Use Component models was to provide an estimate of future cottage development, expressed in units which could be used in the Lakeshore Capacity Study models. The Trophic Status model, for example, required an estimate of annual user-days and the Fisheries Net Productivity model required an estimate of cottage-days. When the various models developed by the individual components were integrated into the Ontario Lakeshore Capacity Simulation Model, predictions from the Land Use Component models became the driving variables.

The practical application of the Land Use Component predictive models is described in this section.

12.1 PREDICTING COTTAGE USE

The Accessibility Model and the Cottager Model were developed by the Land Use Component team to predict the amount of cottage use likely to be generated by a proposed development. When the accuracy of the models was tested, by comparing the model predictions with actual survey data, there was no statistical support for choosing one model over the other. Accordingly, both models should be used.

Thus, the first step is to generate two predictions of cottage use, by applying the Accessibility Model and the Cottager Model. The step-by-step procedure is set out in the User's Guide for the Ontario Lakeshore Capacity Simulation Model (Teleki and Herskowitz, 1982).

12.2 SELECTING THE PREDICTION

The OLCSM should be run with each prediction, to determine the impact on the environment that each would produce. In some cases, the environmental impact will not be sufficient to cause deterioration, so a choice between the cottage-use predictions will not be needed. In other cases, the environmental impact resulting from the higher and lower cottage-use predictions might be substantially different. In such situations, a method of selecting the appropriate cottage-use prediction will be necessary.

With this in mind, various analyses were undertaken in an attempt to determine where each model predicted with greater accuracy, but there were no conclusive results. Also explored was the question of whether the high or low prediction, or their midpoint, was the most accurate. It was evident that the high prediction most closely approached the actual (survey) data where the travel mode was "car all year" and where the proportion of cottages in the All Year group was relatively high. However, the analysis offered no clear directive to assist in selecting the best prediction in other situations.

Consideration was then given to the environmental implications of using a prediction that was too low or too high. If the prediction were too low, the predicted environmental impact would also be too low. Based on this impact, the decision might be to allow more cottages than the environment could actually support. Thus, a low prediction of cottage use could result in damage to the environment.

Conversely, if the predicted cottage use were too high, the predicted environmental impact would also be too high. Based on this impact, the decision might be to allow fewer cottages than the environment could actually support. However, the environment would be protected and it would still be possible to add cottages later if, after monitoring actual change, this proved to be a safe course of action.

In view of these implications for the environment and the lack of clear statistical directives, the higher prediction of cottage use should always be chosen.

12.3 COTTAGE CONVERSION

As the process of "cottage conversion" from seasonal to permanent use is familiar to planners, it may be useful to explain how this process is taken into account in the predictive models.

It was decided at the outset to collect data on actual cottage use, to provide a data base for developing the predictive models. Accordingly, each cottage household in the sample was asked to record actual use of the cottage over a period of twelve months. Cottages used all year therefore included two types: (1) those constructed initially for permanent use, and (2) those converted from seasonal to permanent use. It is the presence of the latter – the converted cottages – which is important in understanding the nature of the model predictions.

As the models were developed from the survey data, the predictions generated by the models take into account the greater number of cottage-days per year associated with converted (and other) permanent cottages.

Analysis of the 1978 Survey of Lakeshore Residents data indicated that the net rate of conversion from seasonal to permanent use was extremely low in the Study Area. This

suggests the possibility that conversions from permanent to seasonal use also occur and may be sufficient to largely offset conversions from seasonal to permanent. In order to obtain more precise information relating to cottage conversion, it is recommended that conversion both to and from permanent use be explored specifically in any survey of cottages that may be undertaken in the future.

12.4 KEEPING THE MODELS CURRENT

The model predictions reflect the 1978 Survey of Lakeshore Residents data on cottage use, from which they were developed. Although changes may occur slowly, over the years changes can be anticipated in the annual amount of cottage use. Some of the factors associated with such change are fuel costs for cars and boats, the level of disposable income, the amount of leisure time available, and family age and composition. While a change in any one of these factors may bring about some change in cottage use, there is no way of predicting how quickly cottagers may react.

There are also strong stabilizing influences which tend to balance the pressures for change. For example, both the school summer vacation period and the climate encourage highest cottage use during July and August.

A new survey of cottages may not be needed for five or ten years, depending on the rate of change. When the Land Use Component data from cottage surveys in 1976 and 1978 were compared, for example, the levels of cottage use were found to be similar over this two-year period. It is recommended that a limited number of lakes that were surveyed in 1978 be monitored periodically in the future, to determine how much change has occurred since 1978. In this way, the pace of change can be determined and the need for a broader survey can be anticipated.

Now that predictive models have been developed and their information requirements established, the time and work involved in a new survey would be substantially less than that required for the original Land Use Component work.

12.5 ADAPTING THE MODELS TO OTHER PARTS OF ONTARIO

The Land Use Component models, which apply at present to the Muskoka-Haliburton Study Area, can be adapted for use elsewhere, wherever data are available regarding cottage use levels and patterns.

The work involved in data collection and analysis would be substantially less than in the original Study Area, now that models are in place and their data needs are known. However, the seasonal use of cottages restricts surveys to July and August, so the preparation stage for the survey work must adhere to a rigid time schedule.

12.6 REFINING THE MODELS IN THE FUTURE

It may be possible in the future to refine the Land Use Component models or to simplify their application. Initially, however, it is strongly recommended that the Land Use Component models be applied in their present form, in accordance with the procedures described in this report.

Particular care must be taken in designating the "travel mode" correctly, as it affects not only the predictive power of the Accessibility Model but also the accuracy of the benchmarking which, in turn, affects the predictive power of the Cottager Model.

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